



March 31, 2005

Sunoco, Inc.
Ten Penn Center
1801 Market Street
Philadelphia PA 19103-1699

Mr. Dale J. Carpenter
Chief, Caribbean Section
RCRA Programs Branch
U.S. Environmental Protection Agency, Region II
290 Broadway
New York, NY 10007-1866

Re: Technical Review of the June 2004 Supplemental RCRA Facility Investigation (RFI) Response, Shell Chemical Yabucoa Inc. (SCYT), Yabucoa, Puerto Rico [Formerly Puerto Rico Sun Oil Company (PRSOC)], EPA ID: PRD090074071

Dear Mr. Carpenter:

Please find enclosed three copies of the "Final RCRA Facility Investigation Report", which are being submitted to you as per EPA's November 23, 2004 letter concerning the above referenced topic.

The additional field work described in our letter of February 12, 2005 was completed. EPA approved this scope of work in a letter dated March 3, 2005, with certain modifications, which were also implemented. The additional work consisted of installation of a supplemental groundwater monitoring well at the Northeast Refinery Area (Well 40-21), groundwater sampling at the well, collection of surface water samples in the bay opposite the Main Dock Sump (SWMU 33), and collection of surface water and sediment samples from Lajas Creek adjacent to the Northeast Refinery Area. The scope and results of the field work at these areas are presented in the Final RFI Report.

As per EPA's November 23, 2004 letter, requested items have been addressed in the final RFI report as follows (item numbers are referenced to those in EPA's letter):

2a) Well construction details for wells installed during the initial and supplemental RFI are discussed in Section 4.2, and presented in Tables 4-1 and 4-2.

2b) The influence of production wells is discussed in Sections 2.8 and 2.9. Production well construction details are provided in Table 2-1.

2c) References to biodegraded product have been changed to degraded product in Sections 5.9, 5-12, 5.16, and 5.17.

2d) Comparison of groundwater results to the Region 3 arsenic risk-based concentration is provided in Section 5.1.2. Comparisons to the current arsenic MCL are provided in the discussions in Section 5 for the various SWMUs.

2e) Comparison to background metal concentrations in soil is provided in the discussion in Section 5 for the various SWMUs at which metals exceeded risk-based screening levels. Background metal levels in soil are also discussed in Section 5.2.1.

2f) Data tables have been updated to include current risk-based screening levels for ingestion/dermal, inhalation of volatiles/particulates in outdoor air, and migration to groundwater.

2g) The occurrence of sample quantitation levels above screening levels is discussed in Section 5.18.1.

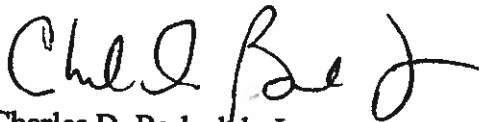
2h) The human health risk to recreational users of Lucia Beach is discussed in Section 7.2.3.

2i) Results of a screening level ecological risk assessment are presented in Section 7.3. Included is a summary of previous bay ecological studies.

Please feel free to call Mr. Bill Morse of Sunoco at 610-859-1553 or Mr. Carlos Martínez of SCYI at 787-893-2424, x2431, if you have any question regarding the above matter.

Thank you.

Cordially,



Charles D. Barksdale Jr.
Manager, Environmental Services /
Corrective Action Project Coordinator

Enclosures:

cc: Mr. Adolph Everett P.E., EPA
Mr. Ernst Jabouin, USEPA
Mr. Julio I. Rodriguez, PREQB
Mr. Carl-Axel Soderberg, EPA-CEPD
Mr. Carlos Martinez, SCYI
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1.0 Introduction

1.1 Summary of RCRA Corrective Action Program

A RCRA Facility Investigation (RFI) has been completed at the Shell Chemical Yabucoa Inc. (formerly Puerto Rico Sun Oil Company, PRSOC) petroleum refining facility located in Yabucoa, Puerto Rico. The RFI was implemented to satisfy the terms of the RCRA 3008(h) Corrective Action Order (Order) signed by PRSOC and the United States Environmental Protection Agency (EPA) in June 1994. Sunoco Inc. (Sunoco) of Philadelphia, PA sold its PRSOC facility to Shell Chemical Yabucoa Inc. (SCYT), on December 31, 2001. However, Sunoco is performing the RFI work on behalf of SCYT.

The RFI was conducted in accordance with the terms of the RCRA Facility Investigation Work Plan (AMAI, 1994), which was initially submitted to EPA in October 1994 and approved by EPA, with certain revisions, in April 1996. The RFI included the investigation of soil and/or groundwater at 16 solid waste management units (SWMUs) identified in the Order. A Process Sewer Assessment was also performed in accordance with the terms of the Order. The report for the Process Sewer Assessment was submitted to EPA in October 1997 (AMAI, 1997).

The objectives of the RFI are summarized below:

- To identify hazardous constituents and their concentrations in soil and/or groundwater at the subject SWMUs
- To determine the potential for contaminant migration by assessing site-specific and regional characteristics that are likely to affect contaminant migration
- To acquire sufficient data to characterize environmental contamination at the SWMUs to support interim or long-term corrective measures, if necessary
- To acquire sufficient data to assess any potential risk to human health and the environment

RFI field activities were conducted between June and August 1996 with certain follow-on activities conducted in January 1997. A Draft RFI Report (AMAI, 1997), which summarized the results of the RFI, was submitted to EPA in June 1997.

In response to EPA comments on the Draft RFI Report, PRSOC submitted a Supplemental RFI Work Plan in March 1999. The objective of the Supplemental RFI was to address a number of data gaps identified by EPA. The Supplemental RFI Work Plan was approved by EPA, with certain revisions, in November 2002 (AMAI, 2002). Supplemental background soil sampling locations were approved by EPA in March 2003. Supplemental RFI field activities were conducted between January and June 2003. A Supplemental RFI Report, which presented the results of the supplemental investigation, was submitted to EPA in June 2003 (AMAI, 2003).

This Final RFI Report consolidates the findings presented in the 1997 Draft RFI Report and the 2003 Supplemental RFI Report. The report also addresses comments provided by EPA in its letter dated November 23, 2004. With this submission, SCYI has satisfied the provisions of Section VI.1 of the 1994 Corrective Action Order.

1.2 Report Organization

A brief description of the organization and content of the remaining sections of this report is presented below.

Section 2 - Section 2 provides a description of SCYI facility operations and the environmental setting of the facility, including topography, meteorology and surface water hydrology as well as regional and site-specific geology and hydrogeology. This information is used as the basis for the conceptual site model of the facility.

Section 3 - Section 3 provides a description of field and laboratory procedures employed in conducting the RFI.

Section 4 - Section 4 presents the results of the groundwater flow and vertical gradient study conducted as part of the RFI.

Section 5 - Section 5 provides a summary of the scope of the RFI field activities and presents the results of the RFI. An overview of soil and groundwater sampling activities

at each SWMU is presented. Results of soil and groundwater sampling and analysis activities are discussed on a SWMU-specific basis. Analytical results are presented in tabular and graphic format.

Section 6 - The mechanisms that influence the fate and transport of organic and inorganic chemicals in the subsurface are discussed in Section 6. The discussion focuses on those chemicals identified at the facility during the RFI.

Section 7 - Section 7 presents a preliminary exposure assessment of the facility based on the results of the RFI. The assessment includes an evaluation of potential migration pathways and potential impacts on human health and the environment.

Section 8 - Findings and conclusions relating to the nature and extent of contamination at the facility are summarized in Section 8.

Section 9 - Section 9 presents references used in development of the report.

2.0 Environmental Setting and Conceptual Model

The environmental setting at the SCYI facility is presented in this section to provide the geologic and hydrogeologic basis for the conceptual site-wide model (CSM). This information along with the contamination assessment addressed in Section 5 of this report defines the CSM. The CSM is used to evaluate site conditions and any contamination scenarios that could lead to an unacceptable threat or exposure at the site. Items discussed include topography, meteorology, surface water characteristics, regional and site-specific geology and hydrogeology, and tidal influences on groundwater level and flow. A description of facility operations is also presented.

This section also presents groundwater level data that were collected during the RFI in 1996-1997 and 2003. Groundwater level data results collected during the Supplemental RFI in 2003 are discussed in more detail in Section 4. Specific geologic, hydrogeologic, and contamination results for the Solid Waste Management Units (SWMUs) investigated during the RFI are discussed in Section 5.

2.1 Facility Location

The SCYI facility is located on Route 901, Km 2.7, Camino Nuevo Ward, about 1.5 miles east of the town of Yabucoa, Puerto Rico. The facility occupies an area of approximately 252 acres which is sub-divided into three working areas: the Refinery Area, the Tank Farm Area, and the Dock Area. The Refinery Area is the most inland area of the facility; the Tank Farm Area is about 2,300 ft east toward the Caribbean Sea; and the Dock Area is further to the east and terminates at the Caribbean Sea. The Dock Area encloses a small man-made inlet (previously referred to as the Turning Basin) which the facility uses for sea transportation purposes.

Maps showing the location of the SCYI facility with respect to the surrounding community, the location of the Refinery, Tank Farm and Dock Areas, and site plans for the Refinery, Tank Farm, and Dock Areas are presented in Figures 2-1 through 2-5. Maps showing the location of the various SWMUs within the Refinery, Tank Farm, and Dock Areas are presented in Figures 2-3 through 2-5.

Agricultural and sugar cane fields surround the facility to the north, east, and west. Route 901 borders the Refinery Area to the south. Route 53 traverses between the Refinery and Tank Farm

Areas. Sugar cane fields are to the south of the Tank Farm Area and a palm tree grove and beach are to the south of the Dock Area. A mountainous area is situated further south of the facility.

The nearest populated area to the facility is the residential community of Camino Nuevo, which has a population of about 4,900, the center of which is located about 2,500 ft southeast of the Refinery Area. The city of Yabucoa is located about 1.5 miles west of the facility.

2.2 Facility Operations

Petroleum refining operations at the facility commenced in May 1971. Prior to the construction of the facility, the property was used as agricultural land. SCYI leases the property upon which the facility is constructed from the Commonwealth of Puerto Rico. Prior to the sale of the facility to SCYI on December 31, 2001, the facility was operated by Puerto Rico Sun Oil Company (PRSOC). There have been no other changes in ownership of the facility.

While operated by PRSOC, the facility complex historically processed 85,000 barrels per day of crude oil. Major products included: reformat, kerosene, light distillates, white oil, naphtha, jet fuel, diesel fuel, No. 2 fuel oil, desulfurized gas oil, lube oil base stocks, residual fuels, aromatic extracts, slack wax and sulfur. Reduced operations occurred between June 2000 and June 2001. The refinery temporarily ceased operation in June 2001, prior to the ownership change in December 2001 to SCYI. After resumption of refinery operations in April 2002 by SCYI, the facility began daily processing of about 75,000 barrels of crude oil to produce gasoline, kerosene aviation fuel, diesel, residual oil, and hydrotreated gas oils for use by Olefin Plants at other facilities for chemical production.

Operations at the SCYI facility are conducted at the three distinct areas mentioned above - the Refinery Area, the Tank Farm and the Dock Area. The three areas are interconnected by a series of above ground pipelines. Further information on each of the areas is provided below.

Refinery Area - The Refinery Area includes SCYI's oil processing operations. The following process units are located at the Refinery Area: crude unit, gas oil desulfurizer, hydrogen unit, sulfur unit, hydrotreater and feed preparation unit, MEK dewaxing unit, UV stabilization and final distillation unit, gasoline reformer and utilities. The MEK dewaxing unit, and UV stabilization and final distillation unit have not been in operation since SCYI acquired the facility in December 2001, however. The Refinery Area also

includes tank storage facilities, administrative and maintenance operations and a waste storage and treatment facility. Figure 2-3 presents a site plan of the Refinery Area. The Refinery Area Wastewater Treatment Plant is located in the northern portion of the Refinery Area.

Tank Farm - Raw materials and products manufactured by SCYI are stored in above ground steel tanks in the Tank Farm Area. Materials are conveyed to and from the Tank Farm via above ground pipelines. The Tank Farm contains approximately 43 crude and product tanks, ranging in size from 500 to 375,000 barrels. Historically, there have been three storage tanks associated with SCYI's ballast water and slop oil management systems. However, SCYI agreed with EPA to remove ballast water handling from SCYI's NPDES permit. As a consequence, ballast water is no longer managed at the Tank Farm Wastewater Treatment Plant, and only one storage tank for slop oil management is used. A tanker truck loading rack is located near the southwestern corner of the Tank Farm. Figure 2-4 includes a site plan of the Tank Farm. The Tank Farm Wastewater Treatment Plant is located in the southeast corner of the Tank Farm.

Dock Facility - SCYI operates a dock facility for the loading and unloading of crude oil and products. The facility includes a Main Dock which serves oil tankers and a Barge Dock which serves smaller vessels and barges. There is also a dock for the servicing of tugboats. Crude oil and products are transferred to and from the Dock Area via aboveground pipelines. There are no storage facilities, process units or any other operations conducted at the Dock Area. Figure 2-5 includes a site plan of the Dock Area.

The SCYI facility is served by several different wastewater collection and treatment systems. The systems are designed to reduce the volume of contaminated wastewater requiring treatment by segregating contaminated and uncontaminated wastewater to the maximum extent possible. At the Refinery Area, collection systems exist for contaminated process wastewater, contaminated stormwater, uncontaminated stormwater, and sanitary wastewater. At the Tank Farm, a collection system is provided for stormwater and tank water drawoff. Collection systems are provided for stormwater at both the Main Dock and the Barge Dock.

Flood protection is provided around the SCYI facility by a series of ditches and earthen dikes. This prevents stormwater from flowing onto the facility property from off-site areas. It also prevents stormwater falling on the SCYI site from flowing onto surrounding land areas.

SCYI has been issued a National Pollution Discharge Elimination System (NPDES) Permit for the discharge of wastewater and stormwater into area surface waters. The Permit allows the discharge of treated process wastewater into the Caribbean Sea through Outfall 001 and the discharge of uncontaminated stormwater into Santiago Creek through Outfall 002. The locations of Outfalls 001 and 002 are shown in Figures 2-5 and 2-3, respectively.

2.3 Topography

The SCYI facility is located within the Yabucoa valley which is surrounded by mountains on three sides and is bordered to the east by the Caribbean Sea. Relatively short rivers and streams originate from the surrounding mountains, traverse the valley, and discharge to the Caribbean Sea.

The altitude of land surface within a 3-mile radius of the facility ranges from sea level to more than 1770 ft above mean sea level (amsl) in the mountains to the south. The highest mountain peak within this radius is Cerro Santa Elena, which is located about 1.6 miles southwest of the Refinery Area. The elevation of the central part of Yabucoa valley north of the Refinery Area is about 16 ft amsl.

The general elevation across the facility increases from northeast to southwest and ranges from sea level at the Dock Area to about 42 feet amsl at the southwestern boundary of the Refinery Area. The average elevations of the Refinery Area, Tank Farm Area, and Dock Area are about 18 ft, 7 ft, and 3 ft amsl, respectively. Topographic relief within the facility areas is mild.

2.4 Meteorology

The climate of Puerto Rico is tropical and is influenced by easterly trade winds which are modified by local land and sea breezes. The easterly winds carry moist air from the east, which rises and cools as it moves inland causing rain showers. The weather from May to November is characterized by cloudiness and rain, occasional tropical storms, flooding rains, and hurricanes. Typically, January through April are the driest months and May through November are the wettest. The average seawater temperature surrounding Puerto Rico, which moderates the climate, is about 27°C (81°F), with little variation throughout the year. The relative humidity over the island averages about 80% during the course of the year.

National Oceanic and Atmospheric Administration (NOAA) climatological data for Yabucoa for a six-year period from 1987 through 1992 showed that rainfall ranged from about 63 to 107 inches, with an average of about 78 inches. The greatest daily rainfall during the six-year period was 10.9 inches. The average rainfall at Yabucoa is somewhat greater than the 30-year island wide annual rainfall average of about 63 inches. Temperature during the six-year period ranged from about 63°F to 91°F, with an average annual temperature of about 78°F. Based on 1993 data, the estimated annual evaporation was 66 inches. Monthly evaporation ranged from 3.4 inches in January 1993 to 7.5 inches in August 1993. The predominant wind direction was from the southeast.

2.5 Surface Water Hydrology

The main inland surface water feature of the Yabucoa valley is the Guayanés River which is located about 1.4 miles northeast of the SCYI facility. The Guayanés, which flows mainly along the east-west axis of Yabucoa Valley, discharges to the Caribbean Sea north of the Dock Area. Surface water flow in the valley is generally from west to east toward the sea. Surface water features are shown in Figure 2-1 and Plate 2.

The nearest surface water features to the facility are Lajas Creek which runs along the eastern border of the Refinery Area and Santiago Creek which runs along the northern border of the Refinery Area. Lajas Creek subsequently enters Santiago Creek about 300 feet north of the Refinery Area. Santiago Creek runs eastward along the northern part of the Refinery Area and discharges to the Caribbean Sea about 1.5 miles to the east. A small unnamed creek runs generally east-west near the northern border of the Tank Farm Area. This creek is also a tributary to Santiago Creek. A second small unnamed creek runs in a northeasterly direction south of the Tank Farm Area. This creek discharges directly to the Caribbean Sea. None of the rivers or streams in the valley are navigable by large vessels. No discharge flow records were available for any of the creeks or rivers.

The largest surface water body in the area is the Caribbean Sea which borders the Dock Area and is about 1.5 miles east of the Refinery Area. In the Dock Area, a small man-made inlet from the Caribbean Sea is used by tanker ships for loading/unloading operations.

The SCYI facility was located within the 100-year flood plain according to the FEMA flood plain map of the area. SCYI built flood control levees to protect the facility areas from potential flood events. The height of these levees exceeds the 100-year flood level.

Stormwater runoff from the refinery process area is intercepted by an underground storm-sewer system; in the Tank Farm Area it is intercepted by the East and West Aisle drainage ditches. Stormwater is also intercepted in the Dock Area.

2.6 Regional Geology

The SCYI facility is situated in the southeastern portion of the Yabucoa valley in southeastern Puerto Rico. The valley, which has a drainage area of about 45 square miles, is surrounded by weathered diorite hills, except towards its eastern margin where it is bordered by the Caribbean Sea. The valley is underlain by a series of complex alluvial deposits comprised of coarse-grained stream channel deposits, finer grained natural levee deposits, and clay-sized sediments typical of flood plain deposits. The alluvial deposits, which occur mainly in the central portion of the valley, cover an area of approximately 15 square miles. The underlying bedrock is composed of diorite and granodiorite bedrock which is weathered to varying degrees.

The inland alluvial deposits grade into coastal marine sediments eastward towards the Caribbean Sea. The alluvium is more than 300 feet thick in the center of the valley and thins toward the hills to the south where the facility is located. Within the alluvial deposits are water-bearing sand strata and lenses of limited areal extent. Bedrock elevations for the eastern portion of the Yabucoa valley determined by the U.S. Geological Survey from borehole and geophysical data (USGS, 1996a) are illustrated in Figure 2-6. Buried bedrock ridges have been identified in the area; one of these ridges trends northeast-southwest through the eastern portion of the Refinery Area to the west of the Tank Farm Area. A bedrock ridge also extends southwestward from the northeastern side of the valley. The bedrock map indicates that a paleochannel is incised in the bedrock between the two ridges roughly parallel to Santiago Creek, with the channel widening further inland.

The upper portion of diorite bedrock has been extensively weathered. The zone of weathered bedrock is about 20 to 50 feet thick. In some areas, the weathered bedrock consists of a crumbly mixture of sand, silt, and clay; in other areas the bedrock has decomposed to clay.

2.7 Site-Specific Geology

The site-specific geology at the SCYI facility is illustrated by five geologic cross-sections constructed across the site. The locations of the five cross-sections, which are identified as cross-sections A-A' through E-E', are shown on Plate 1. The individual cross-sections are presented as Figures 2-7 through 2-11. Geologic cross-sections A-A' and B-B', which are presented as Figures 2-7 and 2-8, respectively, are oriented west to east and begin near the Refinery Area and end at the Dock Area. Cross-sections C-C', D-D', and E-E', which are presented as Figures 2-9, 2-10, and 2-11, respectively, are oriented north to south and begin north of the facility and end near the foothills south of the facility. Cross-section C-C' (Figure 2-9) extends northward to near the center of Yabucoa valley. The geologic divisions shown on the cross-sections were derived from the Unified Soil Classification (USC) system. The USC system was also used for description of soil samples collected during the RFI.

Plate 1 also shows the locations of the borings used to construct the cross-sections and other historical borings which illustrate the deeper geology of the area. All geologic cross-sections described above were derived from pre-existing wells and engineering investigation borings that were installed prior to the RFI. Appendix A presents the historical boring logs.

The depth to bedrock increases from the southern diorite hills to the north toward the center of the valley as illustrated in cross-section C-C' (Figure 2-9). Near the center of Yabucoa Valley the depth to bedrock is over 200 ft. The depth to bedrock also increases eastward toward the Caribbean Sea beneath the Tank Farm and Dock Areas. The depth to bedrock is over 100 ft at the Dock Area.

A portion of the facility site is underlain by a bedrock ridge that trends southwest to northeast from the hills to the south. The ridge underlies the eastern portion of the Refinery Area and the western portion of the Tank Farm Area. Alluvial deposits are generally thin over this ridge and become thicker on the flanks. The ridge partially separates the alluvial sequence in the Refinery Area from that in the Tank Farm Area.

In the Refinery Area, the unconsolidated sediments which overly bedrock are generally composed of clay and silty/sandy clay as illustrated in the geologic cross-sections of Figures 2-7 through 2-11. (As mentioned above, the geologic cross-sections were constructed from boring information collected during various investigations prior to the RFI). The southern area is

mainly underlain by clay. The northern area is composed of interbedded lenses of clay, silty/sandy clay, and sand. The sand lenses appear to be limited in areal extent and isolated from each other. Boring logs (presented in Appendix D) and grain size analyses (presented in Appendix H) performed during the RFI show that the surficial sediments to a depth of about 15 ft bgl vary from medium sand to silt and clay. A detailed geologic description based on the boring logs and grain size analyses for each SWMU is presented in Section 5. The depth to bedrock varies from less than 10 ft bgl at Route 901 near the south side of the Refinery Area to over 60 ft bgl at the north side.

In the Tank Farm Area, the surficial geology is composed of sandy clay, clayey sand, and clay. The deeper geology is mainly composed of interbedded lenses of clay, sandy clay, clayey sand, and sand. Beneath the surficial sandy clay is a sand layer ranging in thickness from 5 to 30 feet which trends north-south. This sand layer pinches out to the west and does not extend to beneath the Refinery Area. Underlying the sand layer are interbedded lenses of clay, sandy clay, clayey sand, and sand. A discontinuous clay unit is found at greater depths. The depth to bedrock varies from about 50 ft to over 80 ft.

In the Dock Area, the surficial geology is composed mainly of sand which has a thickness that varies from about 15 to 45 ft. Underlying the sand layer are interbedded lenses of clay, sandy clay, clayey sand, and sand, which is similar to the Tank Farm Area. The depth to bedrock varies from about 80 to 100 ft at the Dock Area.

The geologic cross-sections presented in Figures 2-7 through 2-11 include notes regarding the range of depths to groundwater at the investigation areas. Since the engineering borings used to construct the cross-sections were not converted to monitoring wells, water level data specific to the cross-sections are not available. Also, none of the cross-sections traversed wells installed during the RFI. As discussed in Section 2.9, the depth to groundwater ranged from about 2 to 14 ft below ground level.

2.8 Regional Hydrogeology

Within the alluvial deposits of the Yabucoa basin are deep water-bearing sand strata which compose the main regional aquifer. These sand strata, located mostly within the central part of the valley, are limited in areal extent. Many of the sand strata are apparently elongated lenses oriented parallel to the valley in an east-west direction. The deeper lenses pinch out and do not

extend southward to the margin of the valley where the SCYI facility is located (see geologic cross-section C-C' of Figure 2-9). Cross-section C-C', which traverses several of the facility production wells, also shows their screen depths. A shallow sand lense with a maximum depth of about 35 ft below ground level (bgl) and a thickness varying from about 4 to 35 ft exists beneath the Tank Farm and Dock Areas, but not the Refinery Area (see geologic cross-sections D-D' and E-E' of Figures 2-10 and 2-11, respectively). This shallow sand lense, which may not be continuous to other portions of the valley, does not likely extend to deeper portions of the Yabucoa basin north of Santiago Creek shown in the bedrock map of Figure 2-6.

Based on aquifer tests conducted at facility water supply wells near the center of the Yabucoa valley, the alluvial aquifer has transmissivities ranging from 21,000 to 40,000 gpd/ft. Storage coefficient data indicate that the aquifers are under semi-confined to confined conditions. Rapid response of water levels to rainfall events in the well field area indicate that leakage occurs through confining layers between the shallow water table aquifer and deeper aquifer zones (Geraghty & Miller, 1987). Well yields vary from 300 to over 1000 gpm. The majority of public and industrial water supply for the area is derived from groundwater resources.

SCYT's current water well production field consists of four wells and extends from about 2300 to 7000 ft north to northwest of the Refinery Area. The locations of the four production wells, which are identified as wells PW-1, PW-2, PW-3, and PW-6, are shown in Figure 2-12. Well PW-4, which is also shown on Figure 2-12, is not in use. Former well PW-8 was abandoned during 1988-89. Available construction details for the production wells are presented in Table 2-1. Average pumping rates from the well field have been as follows: 1600 gpm from 1978 to 1980; 1200 gpm from 1980 to 1993; and 800 gpm from 1993 to 1996 (USGS, 1996a). Average pumping rates reported by the facility during 2002, 2003, and 2004 were 515 gpm, 588 gpm, and 558 gpm, respectively.

The general pre-development groundwater flow direction in the Yabucoa valley aquifer system, which is illustrated in Figure 2-13 was from west to east toward the Caribbean Sea with a gradient of about 10 ft/mile.

A 1990 groundwater elevation map for Yabucoa valley alluvial aquifer developed by the USGS is presented in Figure 2-14. The USGS map shows a cone of depression north and northwest of the facility resulting from groundwater pumping, mainly from the SCYI well field. As a result of the pumping, groundwater levels in the well field area have locally declined such that the

groundwater flow direction is radially toward the well field. Several items should be noted about the applicability of this map with respect to the facility area. Firstly, the facility decreased the pumping rate from the well field in 1993, which suggests that the map is no longer representative and that the cone of depression is less extensive than shown on the map. Secondly, the map was made utilizing many wells that tap deeper aquifer zones not present at the facility. The sediment thicknesses significantly thin toward the south side of Yabucoa Valley at which the facility is located. Thirdly, the USGS map apparently utilized only one well (presumably the Old Construction Well) to define the water levels in the facility area. The Old Construction Well (OCW), which is located at the northern border of the refinery area taps a deeper water-bearing zone. Therefore, although the USGS map of Figure 2-14 may be somewhat useful for evaluating regional groundwater conditions, it does not accurately portray conditions at the SCYI facility. Rather, site-specific data discussed in Section 2.9, should be used for evaluating the groundwater elevation and flow direction characteristics at the facility.

Groundwater levels near the center of Yabucoa valley northeast of the refinery area are monitored on a regular basis by the U.S. Geological Survey (USGS) at well TW-2 (also identified as well Yabucoa 7). The location of well TW-2, which is situated in the central part of Yabucoa valley about 7500 ft north-northwest of SCYI Refinery Area, is shown in Figures 2-12 and 2-14. Figure 2-15 shows the long-term water level record between 1993 and 1997 at USGS well TW-2. The water levels at well TW-2 generally follow seasonal patterns with no apparent long-term trend of increasing or decreasing levels. In general, groundwater levels in the Yabucoa area are highest in September during the rainy season and lowest during the dry months of March and April (USGS, 1996b). During a 5-year period from 1993 to 1997, groundwater elevations at well TW-2 fluctuated from about 2 to 9 ft above mean sea level (amsl) with no obvious decreasing trend. This indicates that there is no long-term influence at this location from pumping at the production wells in the central part of the valley. A similar situation likely exists at the SCYI facility, since the distances from the production wells to well TW-2 and from the production wells to the Refinery Area are similar. Also, since the water level record at well TW-2 does not show any long-term trend of declining water level, groundwater recharge to the aquifer appears sufficient to compensate for groundwater extracted for public and industrial supply.

The general vertical groundwater flow direction in the Yabucoa valley appears to be downward from the uppermost water bearing zone to deeper zones based on data supplied by USGS for a series of nested wells located throughout the valley (USGS, Puerto Rico, 1997; personal

communication with Joe Troester). The locations of the nested monitoring wells used by the USGS are shown in Figure 2-16. Groundwater level and well construction data for these monitoring wells presented in Table 2-2 show that the uppermost water-bearing zone had a higher hydraulic head compared to deeper water-bearing zones indicating downward vertical flow.

2.9 Site-Specific Hydrogeology

Site-specific groundwater level, flow and velocity conditions and aquifer characteristics are discussed in this section. A discussion of groundwater and surface water interconnection issues is also presented.

Groundwater Level and Flow Direction

A groundwater elevation and flow direction maps constructed from synoptic water level measurements collected during the RFI on September 1, 1996 and April 22, 2003 at the SCYI facility are presented in Figures 2-17 and 2-18, respectively. Data used for the construction of the maps is discussed in Section 4.3.1.

Figures 2-17 and 2-18 show that groundwater elevations at the site varied from about 1 ft above mean sea level (amsl) at the Dock Area to over 21 ft amsl in the Refinery Area. The depth to groundwater, which is affected mainly by topographic relief, varied from about 2 to 15 ft below ground level (bgl). The general groundwater flow direction was to the north and northeast within the Refinery Area; to the east and northeast within the Tank Farm Area; and to the east and southeast within the Dock Area. Groundwater exits the Refinery Area generally in a northeast direction.

Historical records for a 5-year period from 1991 to 1996 from groundwater monitoring wells at the equalization basin located in the northeast part of the Refinery Area show a seasonal water level variation of about 5 ft. The seasonal water level changes, which generally followed rainfall cycles, did not significantly affect the groundwater flow direction. The seasonal water level variation decreases in magnitude toward the Caribbean Sea where groundwater elevations are lower.

The production water wells for the facility are the most downgradient water supply wells in Yabucoa valley. They are located north and north-northwest of the Refinery Area; northwest of the Tank Farm area; and generally to the east of the Dock Area. Based on the groundwater flow direction data for the facility, none of the production wells are located downgradient of the site. Therefore, any contamination at the site is unlikely to affect the facility water supply well field or other water supply wells located northeast of the site.

As discussed in Section 2.8, groundwater pumping from the facility water supply wells has resulted in a localized decline in water levels in the well field area northeast of the facility. No apparent effect at the facility from the pumping is observed, however, since the present groundwater flow direction for the facility area (see Figures 2-17 and 2-18) is generally consistent with the regional pre-development and 1990 groundwater flow direction (see Figures 2-13 and 2-14).

Two rounds of groundwater sampling at the OCW have not detected any groundwater contamination in the Northeast Refinery Area. Also, groundwater results at the Northeast Refinery Area discussed in Section 5.9 do not show any contamination above screening levels, which indicates no impact to groundwater irrespective of the groundwater flow direction conditions.

Aquifer Characteristics

The uppermost aquifer zone at the facility is unconfined. During the RFI in September 1996, in order to evaluate the hydraulic characteristics of the uppermost aquifer zone, a pumping test was conducted at the Main Dock Sump Area (SWMU 33). Slug tests were also conducted at the Barge Dock Sump Area (SWMU 34) and at the Northeast Refinery Area. The pumping test used well MDS-3 as the pumping well; well MDS-4 and an existing large diameter well were used as observation wells. The test was run for a 12-hour period followed by a 12-hour recovery period. Water level measurements were collected at well MDS-8 for tidal corrections. A large-scale figure showing the location of the wells is presented in Figure 5-26. Results from the pumping and slug tests, which are presented in Appendix C, are summarized below.

<u>Area</u>	<u>Hydraulic Conductivity (ft/day)</u>
Northeast Refinery Area (well 40-09)	0.4 and 1.2
Barge Dock Sump Area (wells BDS-1 and BDS-6)	greater than 50
Main Dock Sump Area (well MDS-3)	250

The hydraulic conductivity value for the Main Dock Sump Area (SWMU 33) was determined using an effective saturated thickness of 13 ft and a transmissivity value from the pumping test of about 24,500 gpd/ft (3270 ft²/day).

The data indicate that hydraulic conductivity generally increases from the Refinery Area toward the Caribbean Sea. This is consistent with the information presented in the geologic cross sections discussed in Section 2.7, which indicates that more permeable sandy aquifer zones are more predominant in the Tank Farm and Dock Areas. Less permeable silty and clayey water-bearing zones predominate in the Refinery Area.

Results from previous short-term aquifer tests in 1985 indicate aquifer transmissivity values ranging from 490 to 560 gpd/ft at the Refinery Area and from 1,000 to 6,000 gpd/ft in Tank Farm Area (Geraghty & Miller, 1985). These transmissivities are significantly lower than those measured at the Dock area and also in the central part of the valley as discussed in Section 2.8.

Groundwater Velocity

The groundwater gradient at the Refinery Area determined from the groundwater level map of Figure 2-17 is about 20 ft/mile which is two times greater than that at the central part of Yabucoa valley (see Section 3.7). The higher gradient at the side of the valley is attributed to lower aquifer transmissivity. At the Dock Area, which is near the centerline of the valley, the gradient is estimated to be about 5 ft/mile. Average horizontal groundwater velocities were calculated to be about 0.01 ft/day in the Refinery Area, 0.07 ft/day in the Tank Farm Area, and 0.8 ft/day in the Dock Area. The calculations were made using Darcy's Law, the hydraulic characteristics discussed above, and an effective porosity of 0.3.

Vertical Groundwater Flow Direction

The vertical groundwater flow direction appears to change seasonally at the Northeast Refinery Area. Groundwater level data from September 1996 indicated a downward flow direction while data from January 1997 indicated an upward flow direction. The vertical gradient was also upward in April 2003, downward in May 2003, and then upward in June 2003. The vertical gradient in the Tank Farm area at the East API Separator and Watery Oil Separator was downward in April and June 2003. A detailed discussion for the determination of the vertical gradient is presented in Section 4.3.2.

Boring logs presented in Appendix D for the RFI wells at the Northeast Refinery Area indicate that the geology near the water table is generally a sandy clay. Geologic cross-section C-C' presented in Figure 2-9 shows that the underlying geology in the area consists of a clay unit. Although the vertical groundwater flow direction at the Northeast Refinery Area may be downward during certain seasons, the low vertical hydraulic conductivity of the underlying clay inhibits the vertical movement of any contamination from shallow to deep levels. Additionally, as discussed in Sections 5.9, petroleum hydrocarbon contamination detected near the water table in the Northeast Refinery Area has not impacted deeper water-bearing zones. As discussed in Sections 5.11 and 5.12 for the East API Separator (SWMU 3) and Watery Oil Separator (SWMU 43), petroleum hydrocarbons have also not impacted deeper water-bearing zones.

USGS regional data cited in Section 2.8 suggest a downward flow direction from the uppermost to deeper water-bearing zones in upvalley areas. Groundwater discharge to the Caribbean Sea with a corresponding upward flow direction is likely in areas closer to the Sea such as at the Tank Farm and Dock Areas. The site-specific groundwater elevation and flow direction maps for the uppermost aquifer of Figures 2-17 and 2-18 indicates groundwater discharge to the Caribbean Sea with a corresponding upward flow direction.

Groundwater and Surface Water Interconnection

Santiago and Lajas Creeks, which border the northeast Refinery Area, appear to affect the groundwater flow in the local area. In this area, a component of groundwater flow is to the northwest toward Santiago Creek and a component is to the east toward Lajas Creek. Groundwater and surface water level data collected during the RFI show that groundwater levels at wells bordering the creeks varied with respect to surface water levels. The data indicate that

surface water from Santiago Creek is recharging the groundwater and that groundwater is discharging to Lajas Creek. The zone of groundwater and surface water interaction appears to be localized.

During the RFI in 1996, three staff gauges (SG-1, SG-2, and SG-3) were installed in Santiago Creek and one gauge (SG-4) was installed in Lajas Creek to evaluate potential groundwater and surface water interaction. Figure 2-19 shows the locations of the staff gauges, which are adjacent to the Northeast Refinery Area (SWMU 40), and also of monitoring wells in the area. The elevations of the gauges were surveyed to the nearest 0.01 ft. Tables 2-3 and 2-4 present groundwater level data for the monitoring wells during September 1996 and January 1997, respectively. Table 2-5 presents synoptic surface water level data at three of the staff gauges (levels at gauge SG-3 were not available as the gauge was destroyed during a storm).

The relationship between surface water and groundwater interconnection was determined by comparing surface water levels at staff gauges SG-1 and SG-2 in Santiago Creek to groundwater levels at nearby monitoring wells. During September 1996 and January 1997 surface water levels in Santiago Creek were higher than groundwater levels indicating surface water recharge from Santiago Creek to the adjacent groundwater. Additionally, the surface water level at staff gauge SG-4 in Lajas Creek was compared to groundwater levels at nearby monitoring wells 40-10 and 40-12. During September 1996 and January 1997 the groundwater levels were higher than surface water levels in Lajas Creek indicating groundwater discharge to the Creek. The site-wide water elevation and flow map of Figure 2-17 indicates that recharge from and discharge to the creeks is limited to localized areas around the creeks.

A second set of staff gauges was installed in 2003 as part of the Supplemental RFI work to further evaluate the groundwater and surface water interaction at the Santiago and Lajas Creek area. Two gauges (SC-1 and SC-2) were installed in Santiago Creek and two gauges (LC-1 and LC-2) were installed in Lajas Creek. Figure 2-19 shows the locations of the staff gauges, which are adjacent to the Northeast Refinery Area (SWMU 40), and also of nearby groundwater monitoring wells. The elevations of the gauges were surveyed to the nearest 0.01 ft. Surface water levels at the gauges and water levels in nearby groundwater wells were measured quarterly between June 2003 and June 2004. The surface water level at staff gauge LC-1 and nearby monitoring well 40-11 were additionally measured in July 2004.

The surface water level at staff gauge LC-1 was compared with the groundwater elevation at nearby well 40-11. The surface water level at staff gauge LC-2 was compared with the groundwater elevation at nearby well 40-12. The surface water level at staff gauge SC-1 was compared with the groundwater elevation at nearby well 40-15. The surface water level at staff gauge SC-2 was compared with the groundwater elevation at nearby well 40-14A. All of the wells monitor the water-table zone.

Table 2-6 shows the results of the five synoptic surface water and groundwater level measurements during the Supplemental RFI monitoring period. The results show surface water recharge from Santiago Creek, with exceptions during two quarters in the area of gauge SC-1. The results also show groundwater discharge to Lajas Creek, with a minor exception during one quarter in the area of gauge LC-1. Overall, the results were similar to those observed during the earlier September 1996 and January 1997 monitoring period, in that the surface water from Santiago Creek recharges the groundwater and that groundwater discharges to Lajas Creek.

Stream discharge measurements at three locations along Santiago Creek made by the USGS (USGS, 1996a) also suggest that the surface water from Santiago Creek is recharging the groundwater nearby the SCYI facility. However, discharge measurements at a fourth location about one mile upstream of the SCYI facility suggests that groundwater is discharging to the upstream reach of the Creek.

2.10 Tidal Influence

A chart showing the monthly range of ocean tidal fluctuations at Roosevelt Roads Air Station, which is about 19 miles northeast of the SCYI facility, is presented in Figure 2-20. The chart, which illustrates tidal fluctuations for July 1996, shows a monthly tidal maximum range of 1.6 ft. The average diurnal range was 1.0 ft.

During the RFI, groundwater levels were recorded for a 4 to 7 day period using an electronic data logger at three wells near the inlet from the Caribbean Sea. The purpose was to determine tidal affects on groundwater level and flow. Figure 2-21 shows the location of the wells which are identified as wells DA-1 and BDS-1 in the Barge Dock Sump (SWMU 34) area and well MDS-8 in the Main Dock Sump (SWMU 33) area.

Graphs showing tidal groundwater fluctuations at wells MDS-8, BDS-1, and DA-1 are presented in Figures 2-22, 2-23, and 2-24, respectively. Tidal fluctuations at the wells and their distances from the inlet from the Caribbean Sea are summarized below.

<u>Well</u>	<u>Distance from inlet (ft)</u>	<u>Tidal Fluctuation (ft)</u>
MDS-8	20	0.1
BDS-1	25	0.2
DA-1	750	0.01

The data show that tidal effects are diminished significantly at a distance of 750 ft from the Turning Basin. The data also indicate that the groundwater flow direction is unaffected by tidal fluctuations at this distance. Assuming the tidal fluctuations occur nearly synoptically at wells in close proximity to the Turning Basin such as at the Main Dock Sump (SWMU 33) and Barge Dock Sump (SWMU 34), groundwater flow direction at the units is not significantly affected by tidal fluctuations. Therefore, tidal effects are not likely to cause a reversal of groundwater flow direction that would allow any dissolved contamination from the SWMUs at the Dock Area to affect the drinking water supply wells located within the Yabucoa valley. Additionally, the site-specific groundwater elevation and flow direction maps of Figures 2-17 and 2-18 indicates the groundwater flow direction is eastward toward the Caribbean Sea.

3.0 Field Investigation Procedures

This section describes the soil sampling, monitoring well installation, and groundwater sampling procedures utilized for the RFI field work. The analytical methods and quality assurance/quality control (QA/QC) procedures used for the soil and groundwater sampling work are also described. All field investigation procedures and sampling and analysis protocols were consistent with those contained in the approved RFI Work Plan.

3.1 Soil Sampling Procedures

Soil sampling during the 1996 phase of the RFI was performed using split-spoon sampling. The split-spoons were advanced into the subsurface using either a hollow-stem auger drill rig or a tripod rig depending on site access. The hollow-stem auger (HSA) rig was used in accessible areas and the tripod rig was used in areas with limited access. Continuous soil sampling was performed at the sampling locations using 2-ft split-spoon cores. The split-spoons (1.5-in inside diameter) were driven into the ground using the HSA and tripod rigs using a 140-lb hammer with a 30-inch drop. The HSA borings were advanced using the HSA; the split-spoon sampling was then performed through the inside of the auger. The tripod borings were advanced using the split-spoon sampler. The cores were screened visually for staining and also with a photoionization detector (PID). Split-spoon blow counts were recorded to indicate soil conditions. The site geologist also described the soil type and characteristics of the split-spoon cores.

Soil sampling during the 2003 Supplemental RFI was performed using the direct-push soil sampling method. Continuous soil sampling was performed at the sampling locations using 4-ft cores. The cores were screened visually for staining and also with a photoionization detector (PID). The site geologist also described the soil type and characteristics of the split-spoon cores.

All drilling, augering, and sampling equipment was decontaminated before use. The drilling equipment, including rig, augers, etc. was steam cleaned in a designated areas with a pressurized steam cleaner. The split-spoon and direct-push downhole coring equipment was decontaminated between sampling locations using a sequence of tap water/non-phosphate detergent scrub, tap water rinse, isopropanol (pesticide grade) rinse, 10% ultrapure nitric acid rinse, analyte-free water rinse, and air dry.

3.2 Monitoring Well Installation Procedures

During the 1996 RFI work, a total of 46 groundwater monitoring wells were installed. Three of these wells were installed as permanent wells. The remainder were installed as temporary groundwater monitoring points. The Work Plan specified collecting groundwater samples with a Geoprobe/Hydropunch. This would have involved driving a groundwater sampling probe to a specified level, collecting a groundwater sample, and then retracting the sampling probe. Its use is limited to collection of a discrete groundwater sample for a single sampling event. Temporary wells constructed with PVC casing and screen inside a hollow-stem auger (or within the split-spoon boring where access was limited to a tripod rig) were employed for collection of the groundwater samples specified in the Work Plan and to achieve additional goals which could not be obtained with the Geoprobe/Hydropunch. The additional goals were as follows:

- groundwater level observations
- collection of additional groundwater samples in the future, if needed, without remobilizing a drill rig
- free product delineation and thickness measurements
- free product recovery, if needed

During the 2003 Supplemental RFI work, monitoring wells were installed using a hollow-stem auger system with the exception of well 03-11 at the East API Separator, which is discussed below. At each well, an 8-inch outside diameter (OD) well boring was advanced to the total depth using the auger. The well casing and screen were installed through the hollow-stem of the auger. The auger flights were removed one by one as various components of the well were built. The screen and casing string for the wells consisted of a 10-ft length of 2-inch diameter, schedule 40 PVC screen (20-slot) installed near the bottom of the auger boring. The screen was connected to a 2-inch PVC casing installed to above ground level. A sand pack was installed opposite the screen to a depth of about 2 to 3 ft above the top of the screen. A bentonite seal about two ft thick was installed above the sand pack. The borehole annulus was then grouted to the ground surface. A protective steel surface casing with a locking cap was installed at the top of the well.

Well 03-11 at the East API Separator was installed beneath a piperack east of the unit. The well was installed using hand-operated direct-push equipment since access by hollow-stem auger or tripod drilling equipment was not possible. A 2-inch OD boring was advanced to a depth of about 11 ft below ground level (bgl). The screen and casing string for the wells consisted of a 7-

ft length of 1-inch diameter, schedule 40 PVC screen (20-slot) installed at the bottom of the boring. The screen was connected to a 1-inch PVC casing installed to above ground level. A sand pack was installed opposite the screen to a depth of several inches above the top of the screen. A one-ft thick bentonite seal was installed above the sand pack. The borehole annulus was then grouted to the ground surface. A protective steel surface casing with a locking cap was installed at the top of the well.

Well construction diagrams for the wells installed during the 1996 RFI work and 2003 Supplemental RFI work are presented in Table 4-1 of Section 4.

As part of well installation, continuous soil sampling by split-spoon or direct-push was performed at the well locations. The continuous soil samples were screened for quality observations using visual observations and by measuring the headspace of the soil samples with a PID. Step-out borings were not necessary since none of the screening results or subsequent well observations indicated the presence of FPH. The soil samples were described by AMAI's on-site geologist. Geologic logs from the well borings are presented in Appendix D.

The wells were developed by bailing and/or with a centrifugal pump until the purge water was clean or a maximum of about ten well volumes. After development, the wells were allowed to stabilize for a period of at least two weeks prior to performing groundwater sampling activities, FPH observations, and groundwater level measurements.

The elevations of wells were measured to the nearest 0.01 ft by a licenced surveyor. Additionally, a number of existing wells at the facility that needed elevations were surveyed to assist with groundwater elevation and flow direction determinations. The surveyor's report is included in Appendix B.

3.3 Groundwater Sampling Procedures

The groundwater sampling method used for the 1996-1997 RFI work was as specified in the approved RFI Work Plan. Three to five well volumes were initially purged from the wells. Purging was performed with a Teflon bailer or centrifugal pump with polyethylene hose and foot valve. After purging, the water level was allowed to recover to at least 80 percent of the initial water column in the well, or prior to three hours if full recovery was not possible due to low formation yield. The well was then sampled with a Teflon bailer by slowly lowering it into the

well. Groundwater samples for VOCs were collected first, followed by BNAs and dissolved metals. Samples for dissolved metals were field filtered using a 0.45 micron filter. Immediately after sample collection, the sample containers were placed in ice-filled coolers for transport to the lab for analysis.

During the 2003 Supplemental RFI work, groundwater sampling activities were performed according to EPA low-flow guidance (EPA Region II, 1998; and EPA, 2002). The general groundwater sampling procedure was as follows: a PID reading of the headspace was taken upon opening a well; the water level and well depth were measured; the well was purged using low-flow procedures; and the well was sampled using low-flow procedures.

If headspace measurements indicated potential FPH in a well, or if previous FPH thickness measurements at a well suggested potential FPH, its thickness was measured using an electronic interface probe prior to well purging. Groundwater sampling was not performed at any well that had a measurable FPH thickness greater than a sheen. Only well MDS-4 had a measurable FPH thickness (0.06 ft on April 2, 2003), which occurred during the April 2003 sampling event, therefore, the well was not sampled at that time. The source of the FPH at well MDS-4 was due to a pipeline release incident that occurred on January 31, 2002, and subsequently reported to EPA. However, since FPH measurements at the well in June 2003 indicated only a sheen, it was sampled at that time. The sheen at well MDS-4 was removed with an absorbent pad prior to sampling. Wells 40-11, 40-12, 40-21, and BDS-2 also had sheens, which were removed with absorbent pads prior to sampling.

During the 2003 Supplemental RFI work, the wells were sampled after the groundwater indicator parameters (specific conductivity, pH, dissolved oxygen, and redox) of the purge water stabilized to the criteria specified in the EPA guidance for three consecutive measurements taken 5 minutes apart. Samples for VOCs were collected first, followed sequentially by samples for BNAs, total metals, and dissolved metals. The dissolved metal samples were filtered in the field using a 0.45 micron filter. The groundwater samples were collected in bottles containing preservatives supplied by the laboratory. Samples for VOCs and metals were preserved to a pH of less than 2 using hydrochloric acid and nitric acid, respectively, and then placed on ice. BNAs were also preserved on ice. After sample collection, the sample bottles were stored on ice for shipment to the lab.

Well purging and sampling were performed using bladder pumps with the exception of well 3-10A at the East API Separator. At well 3-10A, a peristaltic pump was used for purging and sampling due to the small water column in the well. Dedicated Teflon-lined polyethylene purging/sampling tubing was used at all sampling locations. The bladder pumps were decontaminated between sampling locations using the following sequence: tap water/non-phosphate detergent scrub, tap water rinse, isopropanol (pesticide grade) rinse, 10% ultrapure nitric acid rinse, analyte-free water rinse, air dry, and aluminum foil wrap.

3.4 Analytical Methods and Quality Assurance/Quality Control

During the 1996-1977 RFI work, groundwater and soil samples were analyzed for Target Compound List (TCL) VOCs and BNAs, and/or Modified Skinner List (MSL) metals using Contract Laboratory Program (CLP) methods.

During the 2003 Supplemental RFI work, groundwater samples were analyzed for Target Compound List (TCL) VOCs and BNAs, Modified Skinner List (MSL) metals, antimony, arsenic, and/or lead using the following analytical methods:

- VOCs by low-level CLP methods, with the exception of the sample from well 03-10A. (The groundwater sample from well 03-10A was inadvertently analyzed using SW-846 Method 8270B. However, the accuracy and results of this method are comparable to CLP methods).
- BNAs by SW-846 Method 8270C
- Metals (total and dissolved) by CLP

During the 2003 Supplemental RFI work, soil samples were analyzed for TCL VOCs and BNAs, and/or MSL metals using the following analytical methods:

- VOCs by SW-846 Method 8260B
- BNAs by SW-846 Method 8270C
- Metals by CLP

During the 2003 Supplemental RFI work, surface water samples were analyzed for TCL VOCs, BNAs, and/or MSL metals using SW-846 Method 8260B, SW-846 Method 8270C, and CLP methods, respectively. Sediment samples were analyzed for VOCs and polycyclic aromatic

hydrocarbons (PAHs) using SW-846 Method 8260B and SW-846 Method 8270C-SIM, respectively. The 8270C-SIM (selective ion monitoring) method for PAHs allows for lower detection limits of selected constituents.

QA/QC samples were collected according to the Quality Assurance Project Plan (QAPP) of the approved RFI Work Plan. Groundwater QA/QC samples consisted of equipment blanks and duplicates. Additionally, a trip blank accompanied each sampling cooler containing VOCs. Soil QA/QC samples consisted of equipment blanks and duplicates. The sampling frequency was one of each type of QA/QC sample per twenty program samples for groundwater and the same for soil. A temperature blank was included in each sample cooler; its temperature was recorded by the lab upon receipt.

The groundwater and soil QA/QC equipment blank and duplicate samples were analyzed for the same constituents (VOCs, BNAs, and metals) as the program samples. The groundwater sampling trip blanks were analyzed for VOCs only.

Laboratory analyses for the 1996-1997 RFI work were performed by Core Laboratories, Inc. of Edison, New Jersey. The data were validated using EPA Region II functional guidelines by Dataval, Inc. of Endwell, New York. Laboratory analyses for the 2003 Supplemental RFI work were performed by Accutest Laboratories, Inc. of Dayton, New Jersey. The data were validated by Premier Environmental Inc., of Merrick, NY and Rafael Infante, a certified chemist in Puerto Rico.

4.0 Groundwater Flow and Vertical Gradient Evaluation

This section presents a description of the activities and results of the groundwater flow and vertical gradient evaluation performed for the RFI.

4.1 Objective

The objectives of groundwater flow and vertical gradient evaluation were as follows:

- Provide sitewide data concerning the groundwater elevation and flow direction in the facility area.
- Provide data concerning the groundwater vertical hydraulic gradient at three locations in the Refinery and Tank Farm Areas.

4.2 Scope

Groundwater levels were measured on September 1, 1996 and April 22, 2003, at new and existing facility-wide monitoring wells for evaluation of the groundwater flow direction. Seventy wells were measured for the September 1996 measuring event; 28 of these wells were located in the Refinery Area, 23 wells in the Tank Farm Area, and 19 wells in the Dock Area. Eighty-two wells were measured for the April 2003 measuring event; 30 of these wells were located in the Refinery Area, 31 wells in the Tank Farm Area, and 21 wells in the Dock Area. A large scale map showing the locations of the groundwater level monitoring wells is presented in Plate 2. The water levels were measured at the wells to the nearest 0.01 ft using an electronic water level meter. Construction details of new wells installed during the RFI are presented in Table 4-1. Available construction details of existing groundwater monitoring wells installed for general environmental purposes prior to the RFI that were used for the groundwater level measurements are presented in Table 4-2.

During the initial RFI work, vertical gradient measurements were made using the deep Old Construction Well in the Northeast Refinery Area (SWMU 40) and nearby shallow monitoring wells. Measurements were made in September 1996 and January 1997. The location of the OCW and other wells in the Northeast Refinery Area are shown in Figure 2-19.

During the Supplemental RFI work, vertical gradient measurements were made at three well clusters: one cluster in the Refinery Area and two in the Tank Farm Area. The locations of the well clusters are shown in Figures 2-19, 5-16, 5-19, and Plate 2. The well cluster in the Refinery Area consists of shallow well 40-14A and deep well 40-14B in the Northeast Refinery Area. Well clusters in the Tank Farm Area are located at the East API Separator (SWMU 3) and Watery Oil Separator (SWMU 43). The cluster at the East API Separator consists of shallow well 03-10A and deep well 03-10B. The cluster at the Watery Oil Separator (SWMU 43) consists of shallow and deep wells WOS-4A and WOS-4B, respectively. Wells 40-14A and 03-10A were installed in July 1996 as part of the initial phase of the RFI. Wells 40-14B, 03-10B, and WOS-4A and WOS-4B were installed in February 2003 as part of the Supplemental RFI. Well construction methods are discussed in Section 3.2. Well construction details are summarized in Table 4-1.

Details concerning the relationship of the well cluster screen depths for determination of the vertical gradient are as follows:

- Well 40-14B at the Refinery Area was screened from 28.3 to 38.3 ft bgl, which intercepts a sand zone overlying a silty clay. The upper part of the screen is set opposite the sand zone and the base of the well is set within the clay. Deep well 40-14B was installed 5.5 ft east of shallow well 40-14A. Shallow well 40-14A, which was installed during RFI work in 1996, is screened near the top of the water table. The vertical distance between the midpoint of the screens for wells 40-14A and 40-14B is 20.8 ft.
- Well 3-10B at the East API Separator (SWMU 3) of the Tank Farm Area was screened from 25.1 to 35.1 ft bgl, which intercepts a sand zone overlying a sandy silty clay. The upper part of the screen is set opposite the sand zone and the base of the well is set within the clay. Deep well 3-10B was installed 7 ft east of shallow well 3-10A. Shallow well 3-10A, which was installed during RFI work in 1996, is screened near the top of the water table. The vertical distance between the midpoint of the screens for wells 3-10A and 3-10B is 21.5 ft.
- Well WOS-4B at the Watery Oil Separator (SWMU 43) of the Tank Farm Area was screened from 26.3 to 36.3 ft bgl, which intercepts a sand zone overlying a gravelly, sandy, silty clay. The upper part of the screen is set opposite the sand zone. The bottom

of the screen is about 1 ft above the clay. Deep well WOS-4B was installed 4 ft south of shallow well WOS-4A. Shallow well WOS-4A, which was installed during the Supplemental RFI work in February 2003, is screened across the water table. The vertical distance between the midpoint of the screens for wells WOS-4A and WOS-4B is 21.0 ft.

For vertical gradient purposes, water levels were measured synoptically at the three well clusters in the Refinery and Tank Farm areas on April 22 and May 8, 2003. Quarterly measurements were also made at the clusters between June 2003 and December 2004.

The elevations of wells were measured to the nearest 0.01 ft by a licensed surveyor. The surveyor's report is included in Appendix B.

4.3 Results

4.3.1 Groundwater Level and Flow Direction

The synoptic groundwater elevations for the September 1, 1996 sitewide groundwater monitoring are presented in Table 4-3. The groundwater elevation and flow direction map constructed from the water elevation data is shown in Figure 2-17.

The synoptic groundwater elevations for the April 22, 2003 sitewide groundwater monitoring are presented in Table 4-4. The groundwater elevation and flow direction map constructed from the water elevation data is shown in Figure 2-18. The data show that groundwater elevations at the facility varied from less than 1 ft above mean sea level (amsl) at the Dock Area to over 21 ft amsl in the Refinery Area. The general flow direction was to the north and northeast in the Refinery Area, to the east and northeast in the Tank Farm Area, and to the east and south in the Dock Area. The groundwater flow direction in the Refinery Area was generally toward the central part of Yabucoa Valley. The groundwater flow direction in the Tank Farm and Dock Areas was generally toward the Caribbean Sea. The groundwater flow direction during April 22, 2003 was generally consistent with that determined during September 1, 1996 indicating that large seasonal variations do not occur.

4.3.2 Vertical Gradient

Water level measurements for determining the vertical hydraulic gradient at the Northeast Refinery Area and Tank Farm area were performed during RFI at several nested wells. The results show that the groundwater vertical hydraulic gradient at the Northeast Refinery Area varies seasonally between upward and downward. In the Tank Farm Area, the vertical gradient is downward at the East API Separator (SWMU 3); at the Watery Oil Separator (SWMU 43) the gradient varies seasonally between upward and downward. Details are provided below.

Groundwater level data at the Northeast Refinery Area from September 1996 indicated a downward flow direction while data from January 1997 indicated an upward flow direction. Tables 2-3 and 2-4 present the groundwater level data used for the September 1996 and January 1997 vertical gradient evaluation at the Northeast Refinery Area. The vertical flow observations were made by comparing the water level at the Old Construction Well, which is screened from about 32 to 90 ft bgl, with water levels from nearby wells installed during the RFI which are screened near the water table. In September 1996, the RFI wells indicated a water level about 0.4 ft higher than at the Old Construction Well suggesting a downward flow direction. In January 1997, the RFI wells indicated a water level about 0.3 ft lower than at the Old Construction Well suggesting an upward flow direction. Rainfall amounts were large during August and September 1996 due to tropical storm activity which may have anomalously affected the water level measurements at that time.

Table 4-5 presents the results for the Supplemental RFI vertical gradient evaluation at the Northeast Refinery Area and Tank Farm Area. The vertical gradient results for the Northeast Refinery Area (SWMU 40) show that between April 2003 and December 2004 the vertical gradient varied seasonally between upward and downward, although the upward direction occurred more frequently. The vertical water level differences between the nested wells (40-14A and 40-14B) varied from 0.81 ft in April 2003 to -1.07 ft in May 2003. Since the vertical distance between the midpoint of the well screens is 20.8 ft, the estimated vertical hydraulic gradient varies from 0.039 to -0.051 ft/ft.

The vertical gradient results presented in Table 4-5 for the East API Separator (SWMU 3) show a downward direction during all quarterly measurements between April 2003 and December 2004. The vertical water level differences between nested wells (03-10A and 03-10B) at the East API

Separator varied between -1.86 ft and -3.59 ft. Since the vertical distance between the midpoint of the well screens is 21.5 ft, the estimated vertical hydraulic gradient varied from -0.087 to -0.167 ft/ft.

The vertical gradient results presented in Table 4-5 for the Watery Oil Separator (SWMU 43) between April 2003 and December 2004 show a seasonal variation between an upward and downward direction, although the downward direction occurred more frequently. The vertical water level differences between nested wells (WOS-4A and WOS-4B) at the Watery Oil Separator varied between -0.09 ft and 0.16 ft. Since the vertical distance between the midpoint of the well screens is 21.0 ft, the estimated vertical hydraulic gradient varied from -0.004 to 0.008 ft/ft.

5.0 Field Investigation Program and Results

This section provides a description of the field investigation work performed and the results for each SWMU at the SCYI facility. Section 5.1 provides an introduction to the section including a summary of the scope of the investigation and a discussion on the selection of risk-based screening levels (RBSLs) used for evaluating soil sampling results and screening levels used for evaluating groundwater sampling results. Tentatively identified compounds (TICs) are also discussed in Section 5.1. Section 5.2 provides a description of the soil and groundwater background investigation. Results of the RFI are presented for each SWMU in Sections 5.3 through 5.17. For each SWMU, a description of the scope of the investigation, SWMU-specific geology and hydrogeology, sampling results, and conclusions are provided. Section 5.18 provides an evaluation of the data quality.

5.1 Introduction

5.1.1 Field Investigation Program Overview

All field activities were conducted in accordance with the procedures set forth in the RFI Work Plan and the Supplemental RFI Work Plan. The objective of the investigation was to characterize the nature and extent of any contamination of surface and subsurface soil or groundwater that may have resulted from releases of hazardous constituents from the sixteen SWMUs subject to the investigation. The field program for soil evaluation utilized a combination of detailed chemical analysis and field screening to define the nature and extent of contamination. Field screening was done for BTEX (benzene, toluene, ethylbenzene, xylenes) and PAHs (polycyclic aromatic hydrocarbons) using immunoassay analytical methods. Field screening permitted on-site analysis for selected classes of constituents and was used to focus field investigations. Full chemical analysis included Target Compound List (TCL) volatile organic compounds (VOCs), base/neutral acid extractable compounds (BNAs), and Modified Skinner List (MSL) metals. Selected soil samples were analyzed for physiochemical properties, including grain size analysis, soil moisture, soil pH, cation exchange capacity, and total organic carbon.

The initial field investigation was conducted between May and September 1996. Confirmatory groundwater samples were collected at certain SWMUs in January and February, 1997. Supplemental investigation activities were conducted between January and June 2003. A total of 91 soil samples were collected for VOC, BNA and/or metals analysis. Eight soil samples were collected for physiochemical analysis. A total of 146 soil samples were collected for field screening by immunoassay. The soil samples were collected from various depths at 68 locations.

A total of 50 groundwater monitoring wells were installed. The wells were used for groundwater level observations, collection of groundwater samples, and/or free-phase hydrocarbon (FPH) delineation and thickness measurements.

As discussed in the respective work plans, the selection of soil and groundwater sampling locations was biased toward areas of suspected contamination at the facility. Although minor deviations to the work plan occurred as a result of unexpected field and hydrogeologic conditions, work plans were substantively completed as proposed. The total number of samples collected during the RFI for analysis exceeded the number of samples specified in the work plan.

The locations of the sixteen SWMUs investigated under the RFI are shown in Figure 5-1. SWMU numbers, names and locations are presented in the table below. Eight of the 16 SWMUs are located in the Refinery Area, six SWMUs are located in the Tank Farm Area, and two SWMUs are located in the Dock Area.

SWMU Number	SWMU Name
<i>Refinery Area</i>	
14	Final Retention Basin
17	North Aeration Basin
18	South Aeration Basin
35	Slop Tank 103
36	Dissolved Air Flotation Unit
38	Dewatering Chamber
39	Hazardous Waste Mixing Box
40	Northeast Refinery Area

SWMU Number	SWMU Name
<i>Tank Farm Area</i>	
2	West API Separator
3	East API Separator
43	Watery Oil Separator
44	Ballast Basin Skimmer Area
44A	Ballast Basin Leachate Collection Tank
45	East Aisle Ditch
<i>Dock Area</i>	
33	Main Dock Sump
34	Barge Dock Sump

5.1.2 Soil and Groundwater Screening Levels

Analytical results from the RFI soil sampling program were compared to appropriate screening levels to characterize the soil and/or groundwater quality at each SWMU. Soil quality was evaluated for on-site workers and construction workers using risk-based screening levels (RBSLs) for the ingestion/dermal (direct contact) and inhalation of volatile/particulates in outdoor air exposure pathways. Soil quality was also evaluated using RBSLs for the migration to groundwater exposure pathway. Groundwater quality was evaluated for the ingestion exposure pathway.

Screening levels do not necessarily represent cleanup standards and alone do not trigger the need for response actions or define unacceptable levels of contaminants in soil or groundwater. Rather the purpose of screening levels is to identify and define areas of contamination that do not require further attention or delineation.

Soil

For the soil ingestion/dermal (direct contact) pathway, RBSLs were obtained for an industrial on-site worker exposure scenario from the lower of EPA Region 3 ingestion risk-based concentrations (RBCs)(EPA Region 3, October 2004a) and ingestion/dermal soil screening levels

(SSLs) from EPA's Supplemental Guidance for Developing Soil Screening Levels for Superfund (EPA, 2002). Region 3 risk-based concentrations include an extensive list of constituents that encompasses most of the Target Compound List and Modified Skinner List constituents detected in the soil at the SCYI facility. RBSLs from EPA's SSLs include screening levels for exposure via the ingestion and dermal contact pathways. Use of the lower of EPA Region 3 RBCs and EPA SSLs provides a more conservative evaluation for human exposure, and includes evaluation for the dermal exposure pathway. The lead screening level of 400 mg/kg for the soil ingestion pathway was obtained from EPA OSWER guidelines (EPA, 1994).

RBSLs for the inhalation of volatile/particulates in outdoor air were obtained from EPA SSLs (EPA, 2002) for an industrial exposure scenario.

RBSLs for the migration to groundwater pathway were obtained from EPA SSLs (EPA, 2002) for a dilution-attenuation factor of 20. The migration to groundwater pathway considers leaching of contaminants from soil to groundwater with subsequent ingestion of groundwater. In accordance with EPA guidance (EPA, 1996), use of dilution-attenuation factor of 20 is appropriate for source areas less than 0.5 acre in size. All SWMU and AOC sources at SCYI are less than 0.5 acre in size.

EPA Region 3 RBCs and EPA SSLs were not available for ingestion/dermal, inhalation, and/or migration to groundwater exposure pathways for several of the detected constituents in soil (acetone, 2-butanone, benzo(ghi)perylene, dibenzofuran, 2-methylnaphthalene, and/or phenanthrene). Concentrations for these constituents were compared to soil screening levels from other sources as discussed below.

EPA Region 9 preliminary remediation goals (PRGs) (EPA, Region 9, October 2004b) were employed for inhalation of volatiles in outdoor air screening levels for acetone ($5.8\text{E}+07$ ug/kg) and 2-butanone ($1.4\text{E}+08$ ug/kg).

Texas Natural Resource Conservation Commission (TNRCC) protective concentration levels (PCLs)(TNRCC, March 2004) were employed for soil ingestion/dermal contact RBSLs for benzo(ghi)perylene and phenanthrene (non-carcinogens). TNRCC PCLs for non-carcinogens are

computed using the same methodology as used for EPA SSLs. The exposure factors are also the same, with the exception of the dermal exposure skin area for the dermal exposure pathway. EPA SSLs employ a dermal exposure skin area of 3300 cm², whereas TNRCC PCLs employ a skin area of 2500 cm². A skin area of 3300 cm² is also recommended by EPA (2004c). To account for the difference, TNRCC PCLs were decreased by a factor of 0.89 so as to have equivalence with the exposure factors used for EPA SSLs. The resulting RBSLs for both benzo(ghi)perylene and phenanthrene are 1.7E+07 ug/kg.

TNRCC PCLs were employed for migration to groundwater screening levels for 2-butanone (2.9E+04 ug/kg), benzo(ghi)perylene (4.6E+07 ug/kg), dibenzofuran (3.3E+04 ug/kg), 2-methylnaphthalene (1.7E+04 ug/kg), and phenanthrene (4.2E+05 ug/kg). TNRCC migration to groundwater PCLs were taken from the residential 0.5 acre source area scenario, so as to be consistent with the exposure factors used by EPA (EPA, 2002) to develop migration to groundwater SSLs. No adjustments to TNRCC PCLs were necessary for the migration to groundwater pathway.

Soil results were divided into two categories - surface and subsurface - depending upon sample depth. The surface soil category, which is for a soil depth of 0 to 2 ft, was evaluated for direct contact and inhalation exposure to on-site workers and for migration to groundwater exposure. The subsurface soil category, which is for a soil depth greater than 2 ft, was evaluated for direct contact and inhalation exposure to construction workers and for migration to groundwater exposure. For the purposes of the screening evaluation, RBSLs for on-site workers were also used for construction workers. This results in a more conservative evaluation for construction workers since actual RBSLs for construction workers would be higher than for on-site workers due to less exposure time and frequency.

Additionally, the analytical results for MSL metals in soil were compared to background soil levels at the SCYI facility. The determination of background metal levels is discussed in Section 5.2. All of the MSL metals are found naturally in soils and their occurrence at each SWMU is not necessarily related to SCYI facility operations.

Groundwater

Groundwater screening levels were obtained from EPA Maximum Contaminant Levels (MCLs) and, where MCLs were not available, EPA Region 3 tap water RBCs (EPA Region 3, October 2004a) were used. TNRCC residential groundwater PCLs were used for groundwater screening levels for acenaphthylene (1500 ug/L), benzo(ghi)perylene (73 ug/L), and phenanthrene (73 ug/L), since MCLs and Region 3 tap water RBCs were not available for these three compounds. For lead, the EPA action level of 15 ug/L was used as a groundwater screening level. Concentrations of metals in groundwater reported throughout this RFI report represent dissolved metal concentrations, except where total concentrations are specifically noted.

For detected constituents that have EPA Region 3 tap water RBCs less than MCLs, the detections were also compared to the more conservative of the two values. This occurred only for arsenic. The EPA Region 3 tap water RBC for arsenic is 0.045 ug/L. It should be noted the 0.045 ug/L tap water RBSL is below the reporting limit of available laboratory instrumentation.

Arsenic detections above the EPA Region 3 tap water RBC of 0.045 ug/L, but less the MCL screening level of 10 ug/L, occurred at the following five SWMUs: Northeast Refinery Area (SWMU 40), East API Separator (SWMU 3), Dewatering Chamber (SWMU 38), West API Separator (SWMU 2), and Main Dock Sump (SWMU 33). The detected concentration at these SWMUs varied from 2.8 to 7.1 ug/L. At the Watery Oil Separator (SWMU 43) arsenic occurred at concentrations up to and including 10 ug/L. As will be discussed for the North Aeration Basin (SWMU 17) and the Barge Dock Sump (SWMU 34) in Sections 5.4 and 5.17, respectively, arsenic exceeded its MCL screening level in groundwater at these two units.

Puerto Rico Water Quality Standards (PREQB, 2003) for groundwater protection are the same as EPA MCLs with the exception of antimony, dibromochloromethane, and 1,2,4-trichlorobenzene, for which Puerto Rico standards are lower. The PREQB groundwater standard for antimony is 5 ug/L, whereas the EPA MCL is 6 ug/L. The PREQB groundwater standard for dichlorobromomethane is 5 ug/L, whereas the EPA MCL is 80 ug/L. The PREQB groundwater standard for 1,2,4-trichlorobenzene is 9 ug/L, whereas the EPA MCL is 80 ug/L. Only antimony

is a constituent of concern that has been detected at the SCYI facility. However, antimony did not exceed its PREQB groundwater quality standard.

Surface water results were compared to Puerto Rico Water Quality Standards (PREQB, 2003) for protection of human health. The surface water results were also compared to ecological standards as discussed in Section 7.3.2.1.

5.2 Background Soil and Groundwater Investigation

The objective of obtaining background soil samples as part of the RFI field investigation was to determine the naturally occurring background concentrations of MSL metals in the soil in the vicinity of the SCYI facility. The objective of obtaining background groundwater samples was to determine the shallow groundwater quality at upgradient locations of the Refinery Area and the Dock Area. A comparison of analytical results of investigative samples to background levels can be used to determine if soil or groundwater has been impacted by facility operations.

5.2.1 Background Soil Investigation

Background soil sampling was conducted in accordance with the procedures detailed in the 1994 RFI Work Plan and the 2002 Supplemental RFI Work Plan. A total of 18 soil samples were collected at nine boring locations identified as BG-1 through BG-9 as shown in Figure 5-2. At each location, a sample was collected from a depth of 0-0.5 ft bgl and 3-3.5 ft bgl. Soil samples from locations BG-1, BG-2 and BG-3 were collected in July 1996. Soil samples from locations BG-4 through BG-9 were collected in April 2003.

Each background soil sample was analyzed for MSL metals. Additionally, to ensure that the background soil sample locations have not been impacted by process activities, a soil sample was collected at locations BG-4 through BG-9 and analyzed for VOCs and BNAs. The sample for VOCs was collected from a depth of 1.5-2 ft bgl and the sample for BNAs from a depth of 0-0.5 ft bgl.

The results of the soil background sampling for metals are presented in Table 5-1. The laboratory identified antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, lead, mercury, nickel, selenium, and vanadium at various depths and locations. Results of VOC and BNA analysis, which detected no constituents in excess of RBSLs, demonstrate that background sample locations had not been impacted by facility operations.

Statistical analysis was performed on a data set comprising the 1996 and 2003 sampling results as well as laboratory results of background soil samples collected by Geraghty & Miller, Inc. in

June of 1992. These results are presented in Table 5-2. Statistical analysis of the data was conducted in accordance with the protocol described in the Supplemental RFI Work Plan. Documentation of the statistical analysis is presented in Appendix G.

The revised background levels for metals in soil at the SCYI facility are presented in Table 5-3.

5.2.2 Background Groundwater Investigation

Background groundwater sampling was conducted in accordance with the procedures detailed in the RFI Work Plan at two wells installed during the RFI: one northwest of the Administration Building within the Refinery Area (RA-8) and one west of the Barge Dock Sump within the Dock (DA-1) as shown in Figure 5-2. Samples were collected for BTEX analysis. Wells were installed and sampled in July 1996.

The laboratory results of the groundwater samples collected at DA-1 and RA-8 for BTEX analysis are presented in Table 5-4. BTEX was not detected at these two sampling locations.

5.3 Final Retention Basin (SWMU 14)

The objective of the RFI field investigation at the Final Retention Basin was to determine if groundwater has been impacted by prior operation of the unit. This SWMU was included in the 1994 Consent Order due to the potential for impact to groundwater.

5.3.1 Scope

In accordance with the procedures detailed in the RFI Work Plan, two monitoring wells were installed downgradient of the northeastern corner of the Final Retention Basin. The wells were installed by hollow stem auger equipment at locations FRB-1 and FRB-2 as shown in Figure 5-3. Groundwater samples were collected from both wells in August 1996 and analyzed for VOCs, BNAs and dissolved metals. After the results of the initial groundwater samples were evaluated, a confirmatory groundwater sample was collected at well FRB-2 in January 1997 and was analyzed for dissolved antimony. Well FRB-2 was sampled again in April 2003 during the supplemental investigation and was analyzed for total and dissolved antimony.

In accordance with the RFI Work Plan, no soil samples were collected at this SWMU.

5.3.2 Site-Specific Geology and Hydrogeology

The subsurface soil at the Final Retention Basin generally consists of fill material described as gravelly, silty sand to a depth of a few inches followed by silty sand, sandy silt, and/or clay to the bottom of the boring. Groundwater was encountered during drilling at approximately 8 ft bgl. Based on the site-wide groundwater level maps presented in Figures 2-16 and 2-17, the direction of groundwater flow at the unit is to the northeast.

5.3.3 Results

The results of the laboratory analysis for VOCs are presented in Table 5-5 and summarized in Figure 5-3. The laboratory detected 1,2-dichloroethene in samples from both wells FRB-1 and

FRB-2, but at concentrations less than the groundwater screening level for this analyte. No other VOCs were detected.

The results of the laboratory analysis for BNAs are presented in Table 5-6 and summarized in Figure 5-3. No BNAs were detected in either of the two monitoring wells.

The results of the metals analysis are presented in Table 5-7 and summarized in Figure 5-3. The laboratory identified barium, cadmium, chromium, and lead at various concentrations at wells FRB-1 and/or FRB-2, but at levels less than groundwater screening levels. Antimony was detected in excess of its MCL of 6 ug/L at well FRB-2 at a concentration of 54.7 ug/L during the August 1996 sampling event, but was not detected at well FRB-1. Antimony was not detected in confirmatory samples collected at well FRB-2 in January 1997 and April 2003.

5.3.4 Conclusions

Based on the laboratory analysis of groundwater samples collected from the two monitoring wells, no groundwater screening levels were exceeded for VOCs, BNAs or metals, except for the initial result for antimony at well FRB-2, which had a concentration above the MCL and slightly above the laboratory detection limit. The January 1997 confirmatory sampling results as well as the April 2003 supplemental groundwater sampling results demonstrate that antimony is not present in the groundwater at the Final Retention Basin in concentrations in excess of its MCL of 6 ug/L. It is therefore concluded that the initially reported result of 54.7 ug/L at well FRB-2 was a false positive, which was not representative of actual groundwater conditions.

The results of the RFI sampling program at the Final Retention Basin demonstrate that operation of the unit has not impacted groundwater in the area. No further investigation is warranted at the unit. A Corrective Measure Study is not proposed for this SWMU.

5.4 North and South Aeration Basins (SWMUs 17 and 18)

The objective of the RFI field investigation at the North and the South Aeration Basins was to determine if groundwater has been impacted by operation of the units. These SWMUs were included in the 1994 Consent Order due to the potential for impact to groundwater.

5.4.1 Scope

In accordance with the procedures detailed in the RFI Work Plan, two monitoring wells were installed downgradient of the North and South Aeration Basins at locations AB-1 and AB-2 as shown in Figure 5-4. Groundwater samples were collected from both wells in August 1996 and analyzed for VOCs, BNAs and dissolved metals. A duplicate groundwater sample was also collected from well AB-1.

After the results of the initial groundwater samples were evaluated, confirmatory groundwater samples were collected in January 1997 and analyzed for dissolved lead at well AB-1 and for dissolved antimony at well AB-2. Duplicate samples were also collected from each well during the confirmatory sampling event. In April 2003, well AB-1 was again sampled and analyzed for total and dissolved lead and well AB-2 was sampled and analyzed for total and dissolved antimony.

In accordance with the Work Plan, no soil samples were collected at this SWMU.

5.4.2 Site-Specific Geology and Hydrogeology

The subsurface soil at the Aeration Basins consists of a fill material composed of silty gravelly sand to a depth of approximately 2 ft bgl and silty to sandy clay to approximately 8 ft bgl. Groundwater was encountered during drilling at varying depths ranging from approximately 8 ft bgl to 12 ft bgl. Based on the site-wide groundwater level maps presented in Figures 2-16 and 2-17, the direction of groundwater flow is to the northeast.

5.4.3 Results

The results of the laboratory analysis for VOCs are presented in Table 5-8 for the North Aeration Basin and in Table 5-9 for the South Aeration Basin and are summarized in Figure 5-4. No VOCs were detected in either of the two monitoring wells.

The results of the laboratory analysis for BNAs are presented in Table 5-10 for the North Aeration Basin and Table 5-11 for the South Aeration Basin and are summarized in Figure 5-4. No BNAs were detected in either of the two monitoring wells.

The results of the metals analysis are presented in Table 5-12 for the North Aeration Basin and in Table 5-13 for the South Aeration Basin and are summarized in Figure 5-4. For the August 1996 sampling event, barium, cadmium, cobalt, nickel and chromium were detected at various concentrations at wells AB-1 and/or AB-2, but at levels less than groundwater screening levels. Arsenic was detected at estimated concentrations slightly in excess of its screening level of 10 ug/L (12.3 ug/L primary, 11.4 ug/L duplicate) at well AB-1. Arsenic was not detected at well AB-2.

Lead was detected slightly in excess of its action level of 15 ug/L at well AB-1 at an estimated concentration of 15.9 ug/L during the August 1996 sampling event, but was not detected in either the duplicate sample from the same well or the sample from AB-2. Lead was not detected in confirmatory samples collected at well AB-1 in January 1997 and April 2003.

Antimony was detected in excess of its MCL of 6 ug/L at well AB-2 at a concentration of 50.5 ug/L during the August 1996 sampling event, but was not detected in the sample from well AB-2. Antimony was not detected in confirmatory samples collected at well AB-2 in January 1997 and April 2003.

5.4.4 Conclusions

Based on the laboratory analysis of groundwater samples collected from the two monitoring wells, no applicable groundwater screening levels were exceeded for VOCs, BNAs or MSL

metals, except for the August 1996 result for lead in the primary sample at well AB-1 and antimony at well AB-2. The January 1997 confirmatory groundwater sampling results as well as the April 2003 supplementary sampling results demonstrate that neither lead nor antimony are present in the groundwater at the North and South Aeration Basin at concentrations in excess of respective screening levels. It is therefore concluded that the initially reported exceedances of lead and antimony screening levels were false positives, which were not representative of actual groundwater conditions. Arsenic was detected at well AB-1 at a concentration only slightly above its screening level, but was not detected at well AB-2. Additionally, arsenic was not detected above its screening level at downgradient wells 40-08, 40-10, 40-11, and 40-21 (see Section 5.9).

The results of the RFI sampling program at the North and South Aeration Basin demonstrate that operation of the units have not impacted groundwater in the area. No further investigation is warranted at the units. A Corrective Measure Study is not proposed for these SWMUs.

5.5 Slop Oil Tank 103 (SWMU 35)

The objective of the RFI field investigation at Slop Oil Tank 103 was to determine if the soil in the vicinity of the Slop Oil Tank is contaminated with MSL metals or petroleum hydrocarbons and, if so, to determine if the potential exists for hazardous constituent migration to subsurface soil or to groundwater. This SWMU was included in the 1994 Consent Order due to the potential for impact to soil and groundwater.

5.5.1 Scope

Soil sampling was conducted in accordance with the procedures detailed in the RFI Work Plan at two locations identified as 35-01 and 35-02 as shown in Figure 5-5. A combination of immunoassay field screening for BTEX and PAHs and detailed chemical analyses for VOCs, BNAs, and/or metals was used in the field investigation. Samples were collected in July 1996.

A total of 12 soil samples were collected from 0 to 7.5 ft bgl for various chemical analyses from the two soil borings. Immunoassay field screening was performed on six samples for BTEX and/or PAHs from the borings. Detailed analysis for VOCs, BNAs, and/or metals was performed on samples collected from three depth intervals at location 35-01 and from three depth intervals at location 35-02 to characterize the surface and subsurface soil horizons.

In accordance with the Work Plan, no groundwater samples were collected at this SWMU.

5.5.2 Site-Specific Geology and Hydrogeology

The subsurface soil at the Slop Oil Tank generally consists of fill material described as gravelly silty sand to a depth of approximately 4 ft bgl and clay to a depth of approximately 8 ft bgl. Groundwater was not encountered during drilling. Based on the site-wide groundwater level map presented in Figures 2-16 and 2-17, the direction of groundwater flow at SWMU 35 is to the northeast.

5.5.3 Results

The results of the laboratory analysis for VOCs are presented in Tables 5-14 and 5-15 for surface and subsurface soil, respectively, and are summarized in Figure 5-5. Acetone and 2-butanone were detected in samples from locations 35-01 and 35-02, but at concentrations below RBSLs. These compounds are common laboratory contaminants. No other VOCs were detected.

The results of the laboratory analysis for BNAs are presented in Tables 5-16 and 5-17 for surface and subsurface soil, respectively, and are summarized in Figure 5-5. Phenanthrene was detected in a sample from location 35-01, but at a concentration below RBSLs. No other BNAs were detected.

The results of the laboratory analysis for metals are presented in Tables 5-18 and 5-19 for surface and subsurface soil, respectively, and are summarized in Figure 5-5. Arsenic was detected in surface soil at location 35-01 at a level of 2.1 mg/kg, slightly in excess of its direct contact RBSL of 1.9 mg/kg. However, this level is below the site soil background level for arsenic of 8.7 mg/kg. Barium, beryllium, chromium, nickel, cobalt, lead and vanadium were detected at various depths at 35-01 and/or 35-02, but at concentrations less than RBSLs.

Although staining was noted in the surface soil at 35-01, no residual product was observed in either of the two borings drilled at the Slop Oil Tank. The results of the immunoassay field screening analysis for BTEX and PAHs are presented in Table 5-20. BTEX ranged from non-detect to 6.75 ppm; PAHs ranged from non-detect to 0.75 ppm.

5.5.4 Conclusions

Detailed chemical analysis of the surface and subsurface soil zones did not identify any VOCs, BNAs or metals in excess of RBSLs with the exception of arsenic, which was detected slightly in excess of its direct contact RBSL at one location. However, the level is within background levels of arsenic in soil at the site

The results of the RFI sampling program at Slop Oil Tank 103 demonstrate that operation of the unit has not impacted soil in the area. No further investigation is warranted at the unit. A Corrective Measure Study is not proposed for this SWMU.

5.6 Dissolved Air Flotation Unit (SWMU 36)

The objective of the RFI field investigation at the Dissolved Air Flotation (DAF) Unit was to determine if the soil in the vicinity of the unit is contaminated with MSL metals or petroleum hydrocarbons and, if so, to determine if the potential exists for hazardous constituent migration to subsurface soil or groundwater. This SWMU was included in the 1994 Consent Order due to the potential for impact to soil and groundwater.

5.6.1 Scope of Work

Soil sampling was conducted in accordance with the procedures detailed in the RFI Work Plan at four locations identified as 36-01, 36-02, 36-03 and 36-04 as shown in Figure 5-6. A combination of immunoassay field screening for BTEX and PAHs and detailed chemical analyses for VOCs, BNAs, and/or metals was used in the field investigation. Samples were collected in July 1996.

A total of 20 soil samples were collected from 0 to 7.5 ft bgl for various chemical analyses and other physiochemical descriptions from the four soil borings. Immunoassay field screening was performed on a total of 12 soil samples from four soil borings for PAHs and BTEX. Detailed chemical analysis for TCL VOCs, BNAs and/or MSL metals was performed on samples collected from three depth intervals at location 36-02 and from three depth intervals at location 36-04 to characterize the surface and subsurface soil horizons. In addition, two samples were collected from location 36-04 for physiochemical descriptions.

In accordance with the Work Plan, no groundwater samples were collected at this SWMU.

5.6.2 Site-Specific Geology and Hydrogeology

The subsurface soil at the DAF Unit consists of a few inches of fill material, unconsolidated gravel and silty clay to silty sand, to a depth of approximately 2 ft bgl and silty clay to sandy clay to sand to approximately 8 ft bgl. Groundwater was encountered during drilling at approximately 8 ft bgl at boring 36-01. The results of the physiochemical descriptions and the grain size

distribution graphs are included in Appendix H. Based on the site-wide groundwater level map presented in Figures 2-16 and 2-17, the direction of groundwater flow at SWMU 36 is to the northeast.

5.6.3 Results

The results of the laboratory analysis for VOCs are presented in Tables 5-21 and 5-22 for surface and subsurface soil, respectively, and summarized in Figure 5-6. The laboratory identified acetone, 2-butanone, ethylbenzene, methylene chloride, toluene, and xylene at various depths at location 36-02, but all at concentrations less than RBSLs. Acetone, 2-butanone, and methylene chloride are common laboratory contaminants. No other VOCs were detected.

The results of the laboratory analysis for BNAs are presented in Tables 5-23 and 5-24 for surface and subsurface soil, respectively, and summarized in Figure 5-6. The laboratory identified benzo(a)pyrene in subsurface soil at a depth of 3-3.5 ft bgl at location 36-02 at an estimated concentration of 400 mg/kg, which is slightly in excess of its direct contact RBSL of 200 mg/kg. Benzo(a)pyrene was not detected in any other surface or subsurface soil samples at the DAF unit. The laboratory also identified acenaphthene, anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, carbazole, chrysene, dibenzofuran, benzo(ghi)perylene, phenanthrene, fluoranthene, fluorene, indeno(1,2,3-c,d)pyrene, 2-methylnaphthalene, naphthalene, and pyrene at various depths at location 36-02 and only naphthalene and pyrene in the surface zone at location 36-04, but all at concentrations less than RBSLs. No other BNAs were detected.

The results of the laboratory analysis for metals are presented in Tables 5-25 and 5-26 for surface and subsurface soil, respectively, and summarized in Figure 5-6. The laboratory identified arsenic, barium, beryllium, chromium, cobalt, lead, mercury, nickel and vanadium at various depths, but at concentrations less than RBSLs. No other metals were detected.

Staining and apparent residual petroleum product was noted at borings 36-01 and 36-04. The results of the immunoassay field screening analysis for BTEX and PAHs are presented in Table 5-27. BTEX ranged from non-detect to greater than 35 ppm; PAHs ranged from non-detect to greater than 25 ppm.

5.6.4 Conclusions

Detailed chemical analysis of soil samples at the DAF Unit detected a number of VOCs, BNAs and metals in the surface and subsurface zones. With the exception of benzo(a)pyrene, none of the constituents were detected at concentrations in excess of RBSLs. Benzo(a)pyrene was detected at one location at an estimated concentration slightly in excess of its direct contact RBSL, but was not detected in any other surface or subsurface soil sample at the DAF unit.

The results of the RFI sampling program at the DAF Unit demonstrate that operation of the unit has not significantly impacted soil in the area. No further investigation is warranted at the unit. A Corrective Measure Study is not proposed for this SWMU.

5.7 Dewatering Chamber (SWMU 38)

The objective of the RFI field investigation at the Dewatering Chamber was to determine if the soil and/or groundwater in the vicinity of the unit are contaminated with MSL metals or petroleum hydrocarbons and, if so, to determine if the potential exists for hazardous constituent migration. This SWMU was included in the 1994 Consent Order due to the potential for impact to soil and groundwater.

5.7.1 Scope of Work

Soil Investigation

Soil sampling was conducted in accordance with the RFI Work Plan at four locations identified as 38-01, 38-02, 38-03 and 38-04 as shown in Figure 5-7. A combination of immunoassay field screening for BTEX and PAHs and detailed chemical analyses for VOCs, BNAs, and/or metals was used in the field investigation. Soil samples were collected in July 1996.

A total of 21 soil samples were collected from 0 to 9.5 ft bgl for various chemical analyses and other physiochemical descriptions from the four soil borings. Immunoassay field screening was performed on a total of 12 soil samples from four soil borings for BTEX and PAH analysis. Detailed chemical analysis for VOCs, BNAs and/or metals was performed on soil samples collected from four depth intervals at location 38-02 and from three depth intervals at location 38-04 to characterize the surface and subsurface soil horizons. In addition, two soil samples were collected from location 38-02 and analyzed for physiochemical parameters.

Groundwater Investigation

A groundwater monitoring well was installed at location 38-02 to collect a groundwater sample for chemical analysis and to observe groundwater levels. A groundwater sample was collected from the well and was analyzed for VOCs, BNAs and dissolved metals. The well was installed in July 1996 and sampled in August 1996.

5.7.2 Site-Specific Geology and Hydrogeology

The subsurface soil at the Dewatering Chamber consists of a sandy gravel to silty gravelly sand to a depth of approximately 6 ft bgl and clayey silty sand to approximately 8 ft bgl. Groundwater was encountered during drilling at approximately 8 ft bgl. The results of the physiochemical descriptions and the grain size distribution graphs are included in Appendix H. Based on the site-wide groundwater level maps presented in Figures 2-16 and 2-17, the direction of groundwater flow at SWMU 38 is to the northeast.

5.7.3 Results

Soil Investigation

The results of the laboratory analysis for VOCs in soil are presented in Tables 5-28 and 5-29 for surface and subsurface soil, respectively, and summarized in Figure 5-7. No VOCs were detected in the surface or the subsurface zones.

The results of the laboratory analysis for BNAs in soil are presented in Tables 5-30 and 5-31 for surface and subsurface soil, respectively, and summarized in Figure 5-7. No BNAs were detected in the surface or subsurface zones.

The results of the laboratory analysis for metals in soil are presented in Tables 5-32 and 5-33 for surface and subsurface soil, respectively, and summarized in Figure 5-7. The laboratory identified arsenic, barium, beryllium, chromium, cobalt, lead, mercury, nickel and vanadium at various depths, but at concentrations less than RBSLs. No other metals were detected.

No staining or apparent residual petroleum product was observed in any of the soil borings. The results of the immunoassay field screening analysis for BTEX and PAHs are presented in Table 5-37. BTEX was identified at levels ranging from non-detect to greater than 35 ppm; PAHs ranged from non-detect to greater than 25 ppm.

Groundwater Investigation

The results of the laboratory analysis for VOCs, BNAs and MSL metals in groundwater are presented in Tables 5-34, 5-35, and 5-36 and summarized on Figure 5-8. No VOCs or BNAs were detected in the groundwater. The metals arsenic, barium, cadmium, cobalt, nickel and vanadium were detected, but all at concentrations below groundwater screening levels.

5.7.4 Conclusions

Detailed chemical analysis of soil samples at the Dewatering Chamber did not detect VOCs or BNAs in the surface and subsurface zones. A number of metals were detected in the surface and subsurface zones. However, none of the metals were detected at concentrations in excess of RBSLs.

Detailed chemical analysis of the groundwater sample collected at the Dewatering Chamber did not detect VOCs or BNAs. A number of metals were detected in the groundwater, but at concentrations below groundwater screening levels.

The results of the RFI sampling program at the Dewatering Chamber demonstrate that operation of the unit has not impacted soil or groundwater in the area. No further investigation is warranted at the unit. A Corrective Measure Study is not proposed for this SWMU.

5.8 Hazardous Waste Mixing Box (SWMU 39)

The objective of the RFI field investigation at the Hazardous Waste Mixing Box was to determine if the soil in the vicinity of the unit is contaminated with MSL metals or petroleum hydrocarbons and, if so, to determine if the potential exists for hazardous constituent migration to subsurface soil or groundwater. This SWMU was included in the 1994 Consent Order due to the potential for impact to soil and groundwater.

5.8.1 Scope of Work

Soil sampling was conducted in accordance with the procedures detailed in the RFI Work Plan at three locations identified as 39-01, 39-02, and 39-03 shown in Figure 5-9. A combination of immunoassay field screening for BTEX and PAHs and detailed chemical analyses for VOCs, BNAs, and/or metals was used in the field investigation. Initial samples were collected in July 1996. In April 2003, as part of the supplemental field investigation, program soil samples not collected in 1996 were collected to ensure an RFI completeness goal of 100%.

A total of 14 soil samples were collected from 0 to 16.0 ft bgl for various chemical analyses from the three soil borings. Immunoassay field screening was performed on a total of seven soil samples from three borings for BTEX and PAHs. Detailed analysis for VOCs, BNAs and/or metals was performed on samples collected from four depth intervals at 39-01, one depth interval at 39-02, and two depth intervals at 39-03 to characterize the surface and the subsurface soil horizons.

In accordance with the work plan, no groundwater samples were collected at this SWMU.

5.8.2 Site-Specific Geology and Hydrogeology

The subsurface soil at the Hazardous Waste Mixing Box generally consists of fill material described as gravelly silty sand to a depth of approximately 6 ft. Groundwater was not encountered during drilling. The results of the physiochemical descriptions and the grain size distribution graphs are included in Appendix H. Based on the site-wide groundwater level map

presented in Figures 2-16 and 2-17, the direction of groundwater flow at the Hazardous Waste Mixing Box is to the northeast.

5.8.3 Results

The results of the laboratory analysis for VOCs are presented in Table 5-38 and summarized in Figure 5-9. The laboratory identified acetone, 2-butanone, carbon disulfide and methylene chloride at various depths and locations, but all at concentrations less than RBSLs. Acetone, 2-butanone, and methylene chloride are common laboratory contaminants. No other VOCs were detected.

The results of the laboratory analysis for BNAs are presented in Tables 5-39 and 5-40 for surface and subsurface soil, respectively, and summarized in Figure 5-9. The laboratory identified benzo(a)pyrene, benzo(b)fluoranthene, bis(2-ethylhexyl phthalate), chrysene, and pyrene at various depths at and location, but all at concentrations less than RBSLs. No other BNAs were detected.

The results of the laboratory analysis for MSL metals are presented in Tables 5-41 and 5-42 for surface and subsurface soil, respectively, and summarized in Figure 5-9. The laboratory identified arsenic, barium, beryllium, chromium, cobalt, lead, mercury, nickel and vanadium at various depths and locations, but at concentrations less than RBSLs. No other metals were detected.

Staining was observed at each of the soil boring locations although no evidence of residual product in soil was observed. The results of the immunoassay field screening analysis for BTEX and PAHs are presented in Table 5-43. BTEX was identified at levels ranging from non-detect to greater than 35 ppm; PAHs ranged from non-detect to greater than 25 ppm.

5.8.4 Conclusions

Detailed chemical analysis of soil samples at the Hazardous Waste Mixing Box detected a number of VOCs, BNAs and metals in the surface and subsurface zones. However, none of the constituents were detected at concentrations in excess of RBSLs.

As part routine groundwater monitoring for the equalization basin, a groundwater sample was collected from well MW-RA6 in January 1997 and analyzed it for VOCs. As shown in Figure 5-9, well MW-RA6 is adjacent to the Hazardous Waste Mixing Box and the soil sampling locations. The groundwater results, which are included in Appendix C, showed that no VOCs were detected. Data from prior sampling events at the well showed the same results.

The results of the RFI sampling program at the Hazardous Waste Mixing Box demonstrate that operation of the unit has not impacted soil in the area. No further investigation is warranted at the unit. A Corrective Measure Study is not proposed for this SWMU.

5.9 Northeast Refinery Area (SWMU 40)

The objective of the RFI field investigation at this SWMU was to determine if the soil in the vicinity of several former waste piles in the area is contaminated with petroleum hydrocarbons or MSL metals and, if so, to determine if the potential exists for hazardous constituent migration to subsurface soil or groundwater. Additionally, the area was investigated to determine if prior operation of the Old Oily Sludge Basin has impacted subsurface soil and/or groundwater. This SWMU was included in the 1994 Consent Order due to the potential for impact to soil and groundwater.

Due to the detection of free product during the RFI, the area of soil and groundwater investigation was expanded to encompass the original SWMU, referred to as the Disposal Area Behind the Hazardous Waste Storage Area, and an area to the north of the original SWMU. This modified study area is referred to in this report as the Northeast Refinery Area.

5.9.1 Scope of Work

Soil Investigation

Soil sampling was conducted in accordance with the procedures detailed in the RFI Work Plan at ten locations identified as 40-01 through 40-10 as shown in Figure 5-10. A combination of immunoassay field screening for BTEX and PAHs and detailed chemical analysis for VOCs, BNAs, and/or metals was used in the field investigation. Soil sampling was conducted in June 1996.

A total of 22 soil samples were collected from 0 to 15.0 ft bgl for various chemical analyses and other physio-chemical descriptions from the ten borings. Immunoassay field screening was performed on four soil samples for BTEX and/or PAHs at locations 40-03, 40-04, 40-14A, and 40-14B. Detailed chemical analysis for VOCs, BNAs, and/or metals was performed on soil samples collected from one depth interval from locations 40-04, 40-05, 40-06, 40-07, 40-08, 40-09, and 40-10 and from three depth intervals from 40-01, 40-02, and 40-03. In addition, a

sample was collected at one depth interval from location 40-14 and analyzed for physiochemical parameters. A duplicate sample was collected from location 40-01 for VOC analysis.

Groundwater Investigation

A total of 13 groundwater monitoring wells were installed as part of the initial RFI field investigation. Wells 40-09 and 40-10 were installed as per the RFI Work Plan after free product was discovered prior to the RFI at well MW-RA5. After free product was detected at wells 40-09 and 40-10, the monitoring well network was expanded north and downgradient as shown in Figure 5-12. The nine additional wells, which were described in work plan addendums to EPA, are identified as 40-08, 40-12, 40-14, 40-15, 40-16, 40-17, 40-18, 40-19, and 40-20. The purpose of the additional wells was to delineate the extent of the free product and to provide additional downgradient groundwater sampling locations. The wells were installed in July 1996.

Groundwater samples were collected from locations 40-08, 40-12, 40-14, 40-15, 40-16, 40-17, 40-18, 40-19, and 40-20 for VOCs, BNAs and/or dissolved metals. A duplicate groundwater sample was collected from temporary monitoring well 40-20 for VOC analysis. Samples were collected in August and September 1996. After the initial groundwater samples were evaluated, a confirmatory groundwater sample was collected in January 1997 at location 40-08 and analyzed for dissolved and total antimony.

As part of the supplemental investigation, groundwater samples were collected from a well cluster consisting of existing shallow well 40-14A and newly installed deep well 40-14B (see Section 4 of this report for a description of well 40-14B). Groundwater samples from these wells were analyzed for VOCs. A groundwater sample was also collected from well 40-08 and analyzed for total and dissolved antimony. In addition to the groundwater sampling conducted in accordance with the Supplemental RFI Work Plan, SCYI collected groundwater samples from wells 40-11 and 40-12. Sampling of these wells was intended to provide further support to the 1997 finding that groundwater in the vicinity of the FPH plume has not been impacted as a result of dissolution of FPH. Samples from wells 40-11 and 4-12 were analyzed for VOCs, BNAs and total and dissolved MSL metals.

In February 2005, an additional shallow groundwater monitoring well was installed at the Northeast Refinery Area in order to complete delineation of the FPH observed in the area. The location of the well, identified as 40-21, is shown in Figure 5-10. The well was sampled for VOCs, BNAs and total and dissolved MSL metals on February 23, 2005.

Slug tests were performed to evaluate the hydraulic conductivity of the water bearing zone. A product baildown test was also conducted. A sample of free product was collected from well 40-09 for chemical fingerprint analysis.

Surface Water and Sediment Investigation

Surface water and sediment samples were collected from Lajas Creek, which is located to the east of SWMU 40 as shown in Figure 5-10. The objective of the sampling was to determine if surface water and/or sediment have been impacted by FPH releases observed within the Northeast Refinery Area. The scope of the surface water and sediment investigation was proposed to EPA in a letter dated February 14, 2005 and was approved by EPA on March 5, 2005.

Surface water samples were collected at two locations in Lajas Creek, LC-1 and LC-2, as shown on Figure 5-10. A duplicate sample was also collected at location LC-2. Samples were analyzed for VOCs and BNAs using SW-846 Methods 8260B and 8270C, respectively. The surface water samples were collected from the middle of the creek directly into the sample bottles without any intermediate transfer devices.

Sediment samples were also collected at locations LC-1 and LC-2 in Lajas Creek. A duplicate sample was also collected at LC-2. Sediment samples were analyzed for VOCs and polycyclic aromatic hydrocarbons (PAHs). Samples were collected on February 23, 2005.

The sediment samples from Lajas Creek were collected from the top 0-0.5 ft sediment interval. The samples were collected with a coring device in order to minimize loss of fines. The samples were analyzed for VOCs using SW-846 Method 8260B and for PAHs using SW-846 Method 8270C-SIM. The 8270C-SIM (selective ion monitoring) allows for lower detection limits of

selected constituents in sediment. The sediment samples for PAH analysis were centrifuged prior to analysis to reduce moisture content (increase solids content), also for the purpose of achieving lower detection limits. The percent solids in the samples prior to centrifuging ranged from 72.4 to 78.6 percent. The percent solids after centrifuging ranged from 79.6 to 83.5 percent, and showed a moisture reduction ranging from 3.8 to 10.2 percent. Sediment samples for VOCs were not centrifuged to minimize loss of volatiles.

5.9.2 Site-Specific Geology and Hydrogeology

The subsurface soil within the fenced area of the Northeast Refinery Area generally consists of a fill material composed of a mixture of gravel, sand and silt to a depth of approximately 4 ft bgl underlain by a silty clay to a depth of approximately 16 ft bgl. A clay layer was generally encountered at approximately 12 ft bgl. Groundwater was encountered during drilling at varying depths ranging from 12.5 ft bgl to 15.5 ft bgl.

The subsurface soil outside the fenced area generally consists of zones of sandy silt and sandy clay to a depth of approximately 16 ft bgl. Discontinuous sandy zones with thicknesses less than about 2 ft were encountered in several borings. In some areas, a clay zone was encountered at the bottom of the borings from between 10 to 14 ft bgl. Groundwater was encountered during drilling at varying depths ranging from 7 ft bgl to 14 ft bgl.

The results of the physiochemical descriptions and the grain size distribution graphs are included in Appendix H. Based on the site-wide groundwater level maps presented in Figures 2-16 and 2-17, the direction of groundwater flow at SWMU 40 is to the northeast.

During surface water and sediment sampling activities in February 2005, the width of Lajas Creek at sampling locations LC-1 and LC-2 was 8 and 7 ft, respectively. The channel width does not appear to change significantly seasonally, except during major storm events when flooding in the general area can occur. The water column depths at locations LC-1 and LC-2 were 0.6 ft and 0.1 ft, respectively. The sediment thicknesses at locations LC-1 and LC-2 were 2.2 ft and 0.2 ft, respectively. The flow rate in the creek was about 0.27 ft³/sec. The sediment at locations LC-1

and LC-2 consisted of gravelly, sandy silt with some fragments of decaying vegetation. No FPH or sheen were observed at sampling locations LC-1 and LC-2.

5.9.3 Results

Soil Investigation

The results of the laboratory analysis for VOCs are presented in Tables 5-44 and 5-45 for surface and subsurface soil, respectively, and summarized in Figure 5-10. The laboratory identified acetone, 2-butanone, carbon disulfide, methylene chloride, toluene, and/or xylene at various depths and locations, but at concentrations less than the RBSLs. Acetone, 2-butanone, and methylene chloride are common laboratory contaminants. No other VOCs were detected.

The results of the laboratory analysis for BNAs are presented in Tables 5-46 and 5-47 for surface and subsurface soil, respectively, and summarized in Figure 5-10. The laboratory detected benzo(a)pyrene in subsurface soil at location 40-03 at a depth of 3-3.5 ft bgl at an estimated concentration of 2,600 ug/kg, which exceeds the direct contact RBSL for benzo(a)pyrene of 200 ug/kg. The laboratory also identified benzo(ghi)perylene, bis(2-ethylhexyl)phthalate, chrysene, di-n-butyl phthalate, 2-methylnaphthalene, naphthalene, phenol, phenanthrene, fluorene, and pyrene at various depths at locations, but all at concentrations less than RBSLs. Bis(2-ethylhexyl)phthalate and di-n-butyl phthalate are common laboratory contaminants. No other BNAs were detected.

The results of the laboratory analysis for metals are presented in Tables 5-48 and 5-49 for surface and subsurface soil, respectively, and summarized in Figure 5-10. Arsenic was detected at levels slightly in excess of its direct contact RBSL of 1.9 mg/kg in surface soil at locations 40-02 (2.4 mg/kg) and 40-03 (3.4 mg/kg estimated) and in subsurface soil at 40-03 (3.9 mg/kg estimated) at a depth of 3-3.5 ft bgl. However, these levels are below the site soil background level for arsenic of 8.7 mg/kg. Chromium was detected at a level slightly in excess of its migration to groundwater RBSL of 38 mg/kg in surface soil at location 40-02 (38.2 mg/kg). Nickel was detected at levels in excess of its migration to groundwater RBSL of 130 mg/kg in surface soil at locations 40-02 (153 mg/kg) and 40-03 (233 mg/kg) and in subsurface soil at 40-03 (141 mg/kg).

Selenium was detected at levels in excess of its migration to groundwater RBSL of 5 mg/kg in subsurface soil at location 40-03 (7.6 mg/kg). Barium, beryllium, cobalt, lead, mercury, and vanadium were also detected at various locations and depths, but at concentrations less than RBSLs.

Staining and apparent residual petroleum product were noticed in the soil at locations 40-2, 40-3, 40-7, and 40-8 (within the fenced area). Staining and residual petroleum product were noticed in the soil at a number of the locations outside the fenced area. The results of the immunoassay field screening analysis for BTEX and PAHs are presented in Table 5-53. BTEX levels ranged from non-detect to 6 ppm; PAHs ranged from non-detect to greater than 25 ppm.

Groundwater Investigation

The results of the laboratory analysis for VOCs are presented in Table 5-50 and summarized in Figure 5-11. Acetone, carbon disulfide, toluene, and/or xylene were detected at wells 40-11, 40-12, 40-14A, and 40-14B, but at concentrations below groundwater screening levels. Acetone is a common laboratory contaminant. No other VOCs were detected.

The results of the laboratory analysis for BNAs are presented in Table 5-51 and summarized in Figures 5-11. 2-Methylnaphthalene was detected in excess of its screening level of 24 ug/L at well 40-21 at a concentration of 36.9 ug/L in the primary sample and 30 ug/L in the duplicate. Acenaphthene, fluorene and phenanthrene were also detected at 40-21, but at concentrations below screening levels. Acenaphthene and fluorene were detected at low levels at well 40-11, but at concentrations below groundwater screening levels. The detections at wells 40-11 and 40-21 are likely biased high due to the presence of a sheen at these wells. No other BNAs were identified by the laboratory.

The results of the laboratory analysis for metals are presented in Table 5-52 and summarized in Figures 5-11. The laboratory identified arsenic, barium, cadmium, chromium, and vanadium, but at concentrations less than the groundwater screening levels. The initial antimony concentration exceeded the groundwater screening level of 6 ug/L in monitoring well 40-08 at a concentration of 57.3 ug/L. The confirmatory sample at well 40-08 showed non-detect for antimony.

Free Product Observations

During the initial field investigation in 1996-1997, measurable FPH was observed in several monitoring wells at the Northeast Refinery Area, which were wells 40-09, 40-10, 40-11, 40-15, and 40-18. An FPH sheen or less than 0.01 ft of FPH were also observed at wells 40-12, 40-13, 40-15, 40-16, and MW-RA5. The maximum reported apparent FPH thickness was 1.57 ft at well 40-09 as measured between July 1996 and January 1997. No FPH was observed at well 40-20, which is located east of Lajas Creek. Well 40-20 was destroyed sometime after the RFI investigation by agricultural equipment. A sheen was observed at well 40-21 in February 2003. Table 5-54 presents a summary of product thickness measurements taken in 1996 and 1997 at the Northeast Refinery Area wells. Figure 5-12 shows the locations of the wells and the most recently measured free product thicknesses. The area that exhibits the greatest product thickness is south of and between Lajas and Santiago Creeks. Visual observations have been performed on a weekly basis at Lajas and Santiago Creeks since April 2003. No sheen has been observed. The extent of residual product has been defined at this SWMU.

A product baildown test was conducted at well 40-09 during the RFI to estimate the actual formation product thickness. The results, which are presented in Appendix I, shows an estimated thickness of 0.2 ft. A product yield test conducted at the well indicated a very low recovery yield. Characterization of the free product at well 40-09 by chemical fingerprinting showed a signature indicative of severely degraded No. 4 fuel oil. Free product at nearby well MW-RA5 was also characterized as a different variety of severely degraded No. 4 fuel oil. The specific gravity of the product was determined to be 0.92. The free product characterization results are presented in Appendix I.

Surface Water and Sediment Investigation

The results of the laboratory analysis for VOCs and PAHs in sediment are presented in Tables 5-55 and 5-56, respectively. Only acetone was detected in the samples at levels in excess of sediment screening levels. Since acetone is a common laboratory contaminant, its detection is attributed to a laboratory artifact. No other VOCs or PAHs were detected in the samples.

The results of the laboratory analysis for VOCs and BNAs in surface water are presented in Tables 5-57 and 5-58, respectively. No VOCs or BNAs were detected in the samples.

Results of the surface water and sediment investigation are discussed further as part of the Screening Level Ecological Risk Assessment presented in Section 7.3.

5.9.4 Conclusions

Detailed chemical analysis of soil samples at the Northeast Refinery Area detected a number of VOCs, BNAs and metals in the surface and subsurface zones. With the exception of benzo(a)pyrene, arsenic, chromium, and nickel, none of the constituents were detected at concentrations in excess of RBSLs. Benzo(a)pyrene was detected at one location in subsurface soil at a concentration in excess of its direct contact RBSL, but was not detected in any other surface or subsurface soil sample in the area.

Arsenic was detected in soil at two boring locations at concentrations in excess of its direct contact RBSL. However, the concentrations were below background levels of arsenic. Chromium was detected in soil at one boring location slightly in excess of its migration to groundwater screening level. Nickel was detected in soil at two boring locations in excess of its migration to groundwater screening level. Selenium was detected in soil at one boring location slightly in excess of its migration to groundwater screening level. Neither chromium, nickel, or selenium were detected in groundwater above screening levels at the Northeast Refinery Area, however.

The confirmatory groundwater sampling results at well 40-08 demonstrates that antimony is not present in the groundwater at the Northeast Refinery Area. It is therefore concluded that the initially reported exceedances of antimony screening levels was a false positive, which was not representative of actual groundwater conditions. Additionally, antimony does not exceed screening levels at any other groundwater sampling locations at other SWMUs.

2-Methylnaphthalene was detected in excess of its screening level at newly installed well 40-21, which is adjacent to Lajas Creek. The sample was biased high due to a sheen in the well at the

time of sampling. 2-Methylnaphthalene was not detected in any other well in excess of its screening level nor was it detected in Lajas Creek surface water or sediment. The extent of impact is localized and fully delineated.

Results of the surface water and sediment investigation of Lajas Creek demonstrate that the creek has not been impacted by FPH releases within the Northeast Refinery Area.

Groundwater results from deep well 40-14B show no impact to groundwater above screening levels. This indicates that the groundwater quality further northeast and downgradient is not impacted.

As part of routine groundwater monitoring for the facility equalization basin, groundwater samples were collected from wells MW-RA6 and MW-RA7 in December 1996/January 1997 and analyzed them for TCL VOCs. Wells MW-RA6 and MW-RA7 are respectively near the southwest and southeast corners of SWMU 40 (see Figure 5-12) and near the upgradient boundary of the unit. The groundwater results, which are included in Appendix C, showed that no VOCs were detected. Data from prior sampling events at the wells showed the same results.

A groundwater sample was collected from the Old Construction Well in April 1996 and analyzed for VOCs, BNAs, and total and dissolved metals as part of well abandonment preparations. The results are included in Appendix C. VOCs and BNAs were interpreted to be absent. Total and dissolved metal concentration were below groundwater screening levels. The Old Construction Well is screened at a deeper water-bearing zone from about 32 to 90 ft bgl. The groundwater sampling data from this well showed that deeper water-bearing zones have not been impacted by petroleum contamination detected near the water table.

The original objective of the RFI investigation at the Northeast Refinery Area was to determine if the soil at the unit in the vicinity of several former waste piles was contaminated with petroleum hydrocarbons or MSL metals. The results of the RFI indicate that the soil at the unit has been adequately characterized and that no further action is warranted.

Due to the presence of FPH on the water table within the Northeast Refinery Area, ongoing interim measures product thickness monitoring and recovery will continue.

5.10 West API Separator (SWMU 2)

The objective of the field investigation at the West API Separator was to determine if the soil in the vicinity of the unit is contaminated with petroleum hydrocarbons or MSL metals and, if so, to determine if the potential exists for hazardous constituent migration to subsurface soil or groundwater. . This SWMU was included in the 1994 Consent Order due to the potential for impact to soil and groundwater.

5.10.1 Scope of Work

Soil sampling was conducted in accordance with the procedures detailed in the RFI Work Plan at eight locations identified as 2-01 through 2-08 as shown in Figure 5-13. A combination of immunoassay field screening for BTEX and PAHs and detailed chemical analyses for VOCs, BNAs, and/or metals was used in the soil investigation. Soil samples were collected in July 1996.

A total of 28 soil samples were collected from 0 to 5.5 ft bgl for various chemical analyses from the eight soil borings. Immunoassay field screening was performed on a total of 20 samples from the eight boring locations for BTEX and/or PAHs. Detailed chemical analysis for VOCs, BNAs, and/or metals was performed on samples collected from one depth interval at location 2-01, three depth intervals from location 2-02, two depth intervals from location 2-05 and one depth interval from location 2-08 to characterize the surface and subsurface soil horizons.

Due to a shallower than expected water table, soil samples were not collected from a depth of 9-9.5 ft bgl as originally required in the Work Plan, since this sample depth was below the water table. Groundwater sampling was conducted as part of the supplemental investigation in lieu of the deep soil samples. In February 2003, SCYI installed a groundwater monitoring well to evaluate if potential releases from the sides and bottom of the West API Separator have impacted groundwater. The monitoring well was installed at location 2-09, approximately 15 ft east and downgradient of the unit, as shown in Figure 5-14. The well was installed to a depth of 19.5 ft bgl, which is below the base of the West API Separator. In April 2003, a groundwater sample was collected from well 2-09 and was analyzed for VOCs, BNAs, and total and dissolved metals.

5.10.2 Site-Specific Geology and Hydrogeology

The subsurface soil at the West API Separator generally consists of fill material described as gravelly sand to a depth of a few inches followed by sand to the bottom of the borings. Groundwater was encountered during drilling at varying depths ranging from 1.75 ft bgl to 3.5 ft bgl. Based on the site-wide groundwater level map presented in Figures 2-16 and 2-17, the direction of groundwater flow at SWMU 2 is to the east.

5.10.3 Results

Soil Investigation

The results of the laboratory analysis for VOCs in soil are presented in Tables 5-59 and 5-60 for surface and subsurface soil, respectively, and summarized in Figure 5-13. The laboratory identified acetone at various locations and depths but at concentrations less than RBSLs. Acetone is a common laboratory contaminant. No other VOCs were detected.

The results of the laboratory analysis for BNAs in soil are presented in Tables 5-61 and 5-62 for surface and subsurface soil, respectively, and in Figure 5-13. The laboratory identified only fluoranthene and pyrene at location 2-05, but at concentrations less than RBSLs. No other BNAs were detected.

The results of the laboratory analysis for the MSL metals in soil are presented in Tables 5-63 and 5-64 for surface and subsurface soil, respectively, and summarized in Figure 5-13. Arsenic was detected in surface soil at a level slightly in excess of its direct-contact RBSL of 1.9 ug/kg at locations 2-02 (3.3 mg/kg), and in subsurface soil at location 2-05 (3.5 mg/kg) at a depth of 3-3.5 ft bgl, and at location 2-08 (3.2 mg/kg) at a depth of 2.5-3 ft bgl. However, these levels are below the site soil background level for arsenic of 8.7 mg/kg. Barium, beryllium, chromium, mercury, nickel, cobalt, lead and vanadium were also detected at various locations and depths but at concentrations less than RBSLs.

Groundwater Investigation

Groundwater sampling results are presented in Tables 5-65, 5-66, and 5-67 for VOCs, BNAs, and metals, respectively, and are summarized in Figure 5-14. No VOCs, BNAs, or metals were detected in the groundwater sample from well 2-09 above groundwater screening levels.

Free Product Observations

No residual petroleum product was observed in any of the borings drilled at the West API Separator. Staining was noticed in the surface soil at location 2-08. The results of the immunoassay field screening analysis for BTEX and PAHs are presented in Table 5-68. BTEX was identified at levels ranging from non-detect to greater than 35 ppm; PAHs were identified at levels ranging from non-detect to greater than 25 ppm.

5.10.4 Conclusions

Detailed chemical analysis of soil samples at the West API Separator did not detect VOCs or BNAs in the surface and subsurface zones in excess of RBSLs. Arsenic was detected at three locations at concentrations in excess of its direct contact RBSL. However, these concentrations were below background levels of arsenic found at the site. A number of other metals were detected in the surface and subsurface zones but all at concentrations below RBSLs.

Detailed chemical analysis of the groundwater sample collected at the West API Separator did not detect VOCs, BNAs, or metals in groundwater at concentrations in excess of groundwater screening levels.

The results of the RFI sampling program at the West API Separator demonstrate that operation of the unit has not impacted soil or groundwater in the area. No further investigation is warranted at the unit. A Corrective Measure Study is not proposed for this SWMU.

5.11 East API Separator (SWMU 3)

The objective of the field investigation at the East API Separator was to determine if the soil in the vicinity of the unit is contaminated with petroleum hydrocarbons or MSL metals and, if so, to determine if the potential exists for hazardous constituent migration to subsurface soil or groundwater. This SWMU was included in the 1994 Consent Order due to the potential for impact to soil and groundwater.

5.11.1 Scope of Work

Soil Investigation

Soil sampling was conducted in accordance with the procedures detailed in the RFI Work Plan at nine locations identified as 3-01 through 3-09 as shown in Figure 5-15. A combination of immunoassay field screening for BTEX and PAHs and detailed chemical analyses for VOCs, BNAs, and/or metals was used in the field investigation. Soil sampling was conducted in June and July 1996.

A total of 36 soil samples were collected from 0 to 10.5 ft bgl for various chemical analyses from the nine soil borings. Immunoassay field screening was performed on a total of 27 samples from nine locations for BTEX and PAHs. Detailed chemical analysis for VOCs, BNAs, and/or metals was performed on soil samples collected from one depth interval at location 3-01, three depth intervals at location 3-03, one depth interval from location 3-07, three depth intervals at location 3-08, and one depth interval at location 3-09 to characterize the surface and subsurface soil horizons.

Groundwater Investigation

Four shallow groundwater monitoring wells were installed at the East API Separator at locations 3-07, 3-09, 3-10 and 3-11 as shown on Figure 5-16. Wells 3-07, 3-09 and 3-10 were installed in June and July 1996 as per the RFI Work Plan to collect groundwater samples for chemical analyses and to observe groundwater levels. Well 3-11 was installed in April 2003 as part of the